ROBOTICS ■ MICROCONTROLLERS ■ COMPUTER CONTROL ■ SPACE

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EVERYTHING FOR ELECTRONICS

DECEMBER 2005
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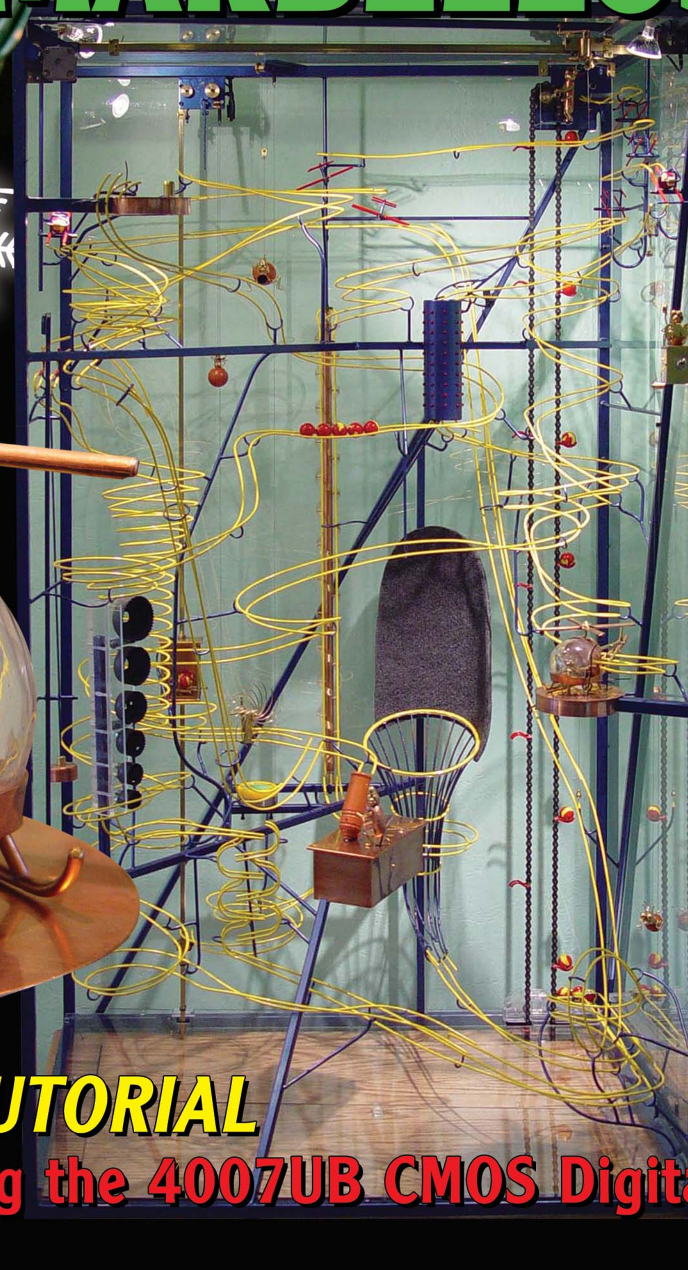
THE FLYING MARBELLOS



■ Kinetic Art, Bugs, and Stamps, Oh My!

■ Poor Man's CNC Machine

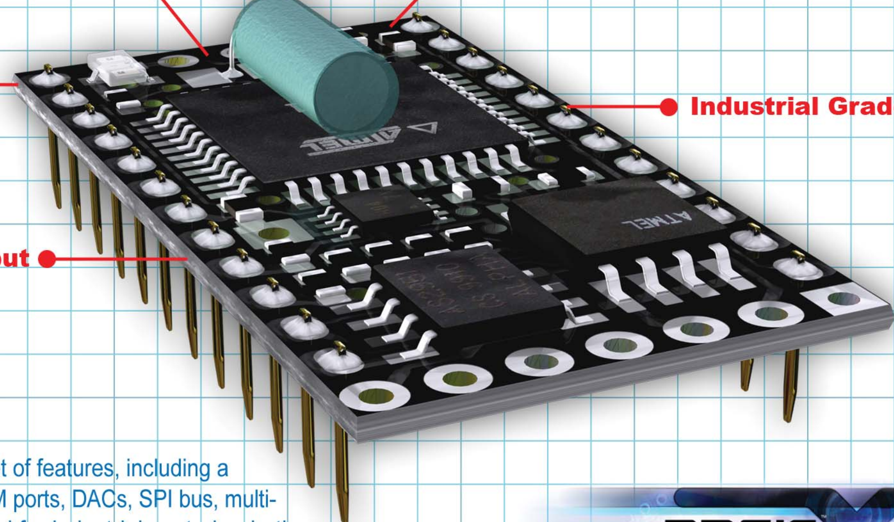
■ Internet Telephones

■ TUTORIAL
Using the 4007UB CMOS Digital IC

Announcing the BasicX - BX24-P

The *fastest* Basic programmable microcontroller...

Just Got BETTER for the same price $49.95



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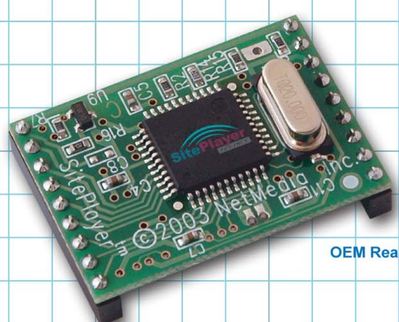
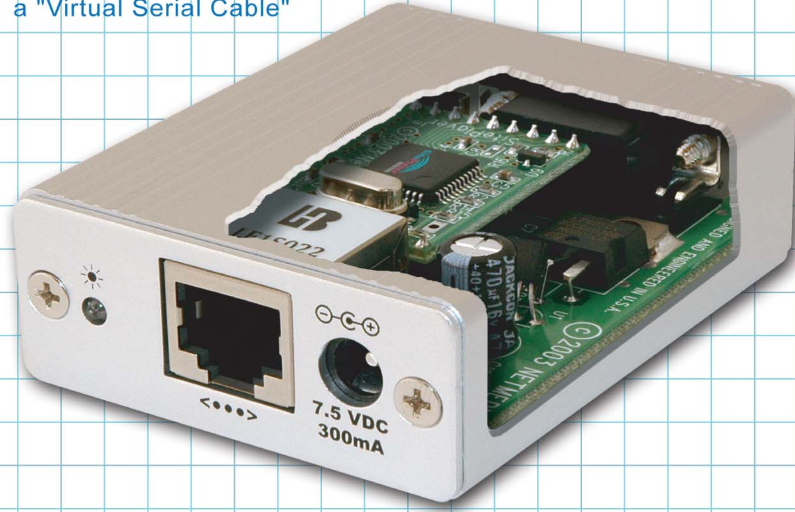


OEM Ready



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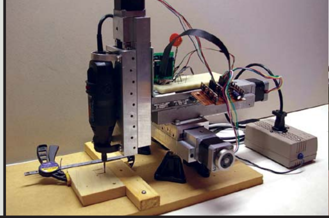

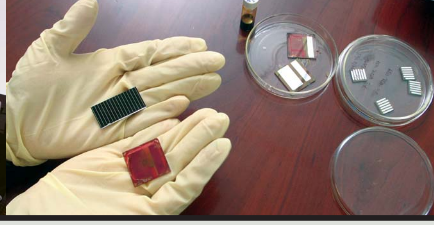

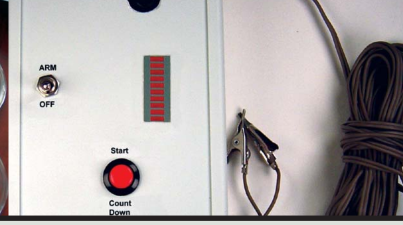

NUTS AND VOLTS

DECEMBER 2005

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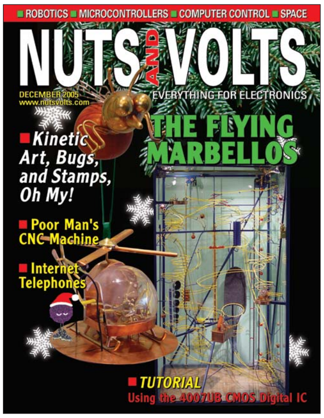

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READER FEEDBACK

PATENT PROBLEM

I am surprised that your article "I Love my Heils! got past your scrutiny with the credit of Dr. O. Heils' patenting of the field effect transistor in 1934. I believe the credit for both the transistor and the FET went to Dr. William Shockley, John Bardeen, and Walter Brattain in 1947. Shockly developed the theory of junction transistors in 1948 and the field effect transistor in 1952. The team shared the Nobel Prize in Physics in 1956 for their work. I believe the actual US patents were held by Bell Labs.

T. Tofte

MISS SIMPLE CIRCUITS

I was a reader of *Radio Electronics* until it dissapeared, and have been with you guys for four years. I only miss a section where new technology was explained with simple words or simple circuits, nothing more involved with it. I bet you can do the same articles, just to be in shape with new advances in electronics. Hope you take this in consideration, not everything is PIC programming!!

Ruben Lara

MORE PICS PLEASE

I love your magazine! Back in 2000, I requested more PIC micro projects and related articles. Your staff came through. It's great when a business listens to their customer base.

Gary
Vancouver USA

TIPS FOR TECHS, TOO

The "In The Trenches" column (October 2005) on the hiring and career tips for engineers also applies to TECHNICIANS.

They are assuming many of the high level design-related work that used to be done only by engineers.

Although the column stated that performance matters more than credentials, today almost all employers require new entry-level technical people to be degreed (BS degree for engineers, and two-year Associate's degree for technicians).

While in the past, technicians were regarded as just "assistants" with inconsistent recognition, they are now regarded as full professionals, along side engineers and computer specialists. The Associate's degree programs for technicians are offered in community

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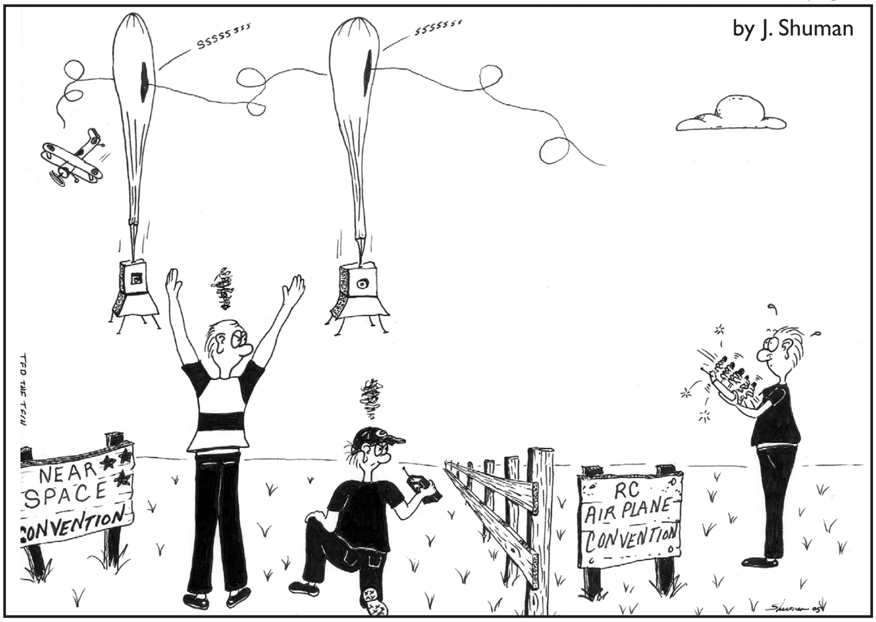

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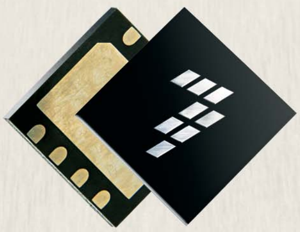
8-bit Microcontrollers



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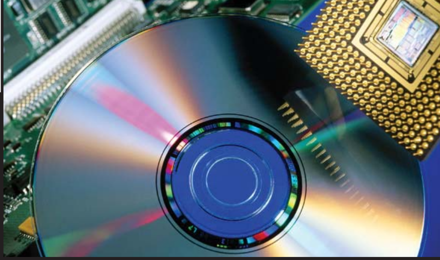


TECH KNOWLEDGEY 2005

EVENTS, ADVANCES, AND NEWS

■ BY JEFF ECKERT

ADVANCED TECHNOLOGIES

NANOSCALE OSCILLATORS GENERATE MICROWAVES

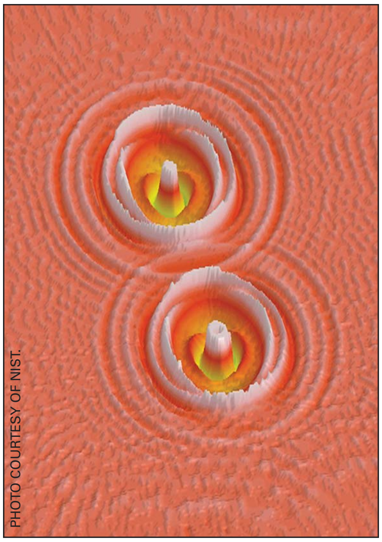


PHOTO COURTESY OF NIST.

■ A SIMULATION MADE WITH MICROMAGNETIC SOFTWARE SHOWS THE INTERACTION OF "SPIN WAVES" EMITTED BY TWO NANO-OSCILLATORS.

According to scientists at the National Institute of Standards and Technology (NIST, **www.nist.gov**), the signals emitted by multiple nanoscale oscillators can naturally synchronize under certain conditions, thus greatly amplifying their output power and stabilizing their signal pattern. While an individual oscillator has a signal power of just 10 nanowatts, total power output can be boosted by synchronizing a collection of devices located 500 nanometers apart. NIST research suggests that small arrays of 10 nano-oscillators could produce signals of 1 microwatt or more, sufficient for practical use as reference oscillators or directional microwave transmitters and receivers in devices such as cell phones, radar systems, and computer chips.

The NIST-designed oscillators consist of a sandwich of two magnetic films separated by a nonmagnetic layer of copper. Passing an electrical current through the device causes the direction of its magnetization to switch back and forth rapidly, producing a microwave signal. The circular devices are 50 nanometers in diameter, which is about 1/1,000 of the width of a human hair and hundreds of times smaller than the typical microwave generators. The devices are compatible with conventional semiconductor technology, which is expected to make them inexpensive to manufacture.

Oddly enough, this type of signal locking was first described by the 17th-century Dutch scientist Christiaan Huygens, who found that two pendulum clocks mounted on the same wall synchronized their ticking, thanks to weak coupling of acoustic signals through the wall. This phenomenon also occurs in many biological systems, such as the synchronized flashing of fireflies, the singing of certain crickets, and circadian rhythms in which biological cycles are locked to the sun. When an electric current passes through the NIST oscillators, the electrons in the current align their spins to match the orientation of the first magnetic layer in the device. When the aligned electrons flow through the second magnetic layer, the spin of the electrons is transferred to the film. The result is that the magnetization of the film oscillates much like a spinning top. This generates a microwave signal that can be tuned from less than 5 GHz to more than 35 GHz by manipulating the current or an external magnetic field.

CHEAP SOLAR CELLS ON THE WAY

With oil and gas prices hovering at an all-time high, interest in renewable energy alternatives is a hotter topic than ever, and researchers at the UCLA (**www.ucla.edu**) Henry Samueli School of Engineering and Applied Science hope to meet the growing demand with a new and more affordable way to harness the sun's rays: using solar cell panels made out of everyday plastics. Engineering professor Yang Yang, postdoctoral researcher Gang Li, and graduate student Vishal Shrotriya recently described their work on an innovative new plastic (polymer) solar cell they hope eventually can be produced for only 10 to 20 percent of the current cost of traditional cells. The price of quality traditional solar modules typically is prohibitive for widespread use, with the cost of solar-generated power running around three to four times more expensive than that derived from fossil fuel. While prices have dropped since the early

■ UCLA ENGINEERING'S PLASTIC SOLAR CELL (RIGHT HAND) AND A REGULAR SILICON SOLAR CELL (LEFT HAND).

PHOTO COURTESY OF MISA/MISA.COM

1980s, the solar module itself still represents nearly half of the total installed cost of a traditional solar energy system. But if they can be produced from cheap plastic rather than highly refined and purified silicon, solar power could become highly practical.

Made of a single layer of plastic sandwiched between two conductive electrodes, UCLA's solar cell is easy to mass-produce and costs much less to make — roughly one-third of the cost of traditional silicon solar cell technology. The polymers used in its construction are commercially available in such large quantities that Yang hopes cost-conscious consumers worldwide will quickly adopt the technology.

At present, the plastic cells are only about 4.4 percent efficient in converting solar energy into electricity. However, Yang believes he will be able to double that number in a very short time and is targeting an ultimate performance level of 15 to 20 percent efficiency, with a 15-20 year life span. The devices could be commercially available in a few years.

COMPUTERS AND NETWORKING

OFFICE SUITE UPGRADE RELEASED

If you have a machine that runs Solaris or Linux, you may want to take a look at the StarOffice 8 suite from Sun Microsystems (www.sun.com). Consisting of five components (Writer, Impress, Calc, Draw, and Base), the new version claims seamless compatibility with Microsoft Office, an improved multipaned user interface, support for the OASIS OpenDocument file format, support for XForms (a W3C standard for XML-based forms), and dozens of other enhancements. It also allows you to convert files directly to PDF, perform advanced data analysis in spreadsheets with DataPilot, merge form letters with address book information, and set up a new database or connect to mySQL, ADO, Oracle, ODBC, and JDBC (Java DataBase Connectivity) software databases. You can download the entire package for $69.95 or get a 90-day trial version for free. For enterprise users, it can be licensed on a per-user basis starting at $35 per user. In addition to the English-language version, it is available in Simplified Chinese, Traditional Chinese, Japanese, and Korean as the StarSuite software.

WI-FI CONSORTIUM FORMED

Twenty-seven Wi-Fi® industry leaders recently announced a coalition formed to accelerate the IEEE 802.11n standard development process and promote a technology specification for next-generation wireless local area networking (WLAN) products. By introducing a specification with widespread industry support, the Enhanced Wireless Consortium (EWC) hopes to speed ratification of an 802.11n standard, while enabling an ecosystem of high-performance WLAN products built to a common set of guidelines. This widely adopted specification will benefit consumers by, among other things, ensuring the interoperability of next-generation wireless products across a variety of brands and platforms.

The EWC has developed a specification that is designed to enable consumers to see new levels of wireless performance, coverage, and interoperability prior to ratification of an 802.11n standard. The specification defines technologies that address the PC and networking equipment market, as well as emerging handheld and consumer electronic applications. The consortium has designed its specification to support speeds of up to 600 Mbps and is considering the inclusion of other advanced technologies — e.g., space time block coding (STBC) and beamforming — that will enable systems to deliver greater range for wireless products across multiple market segments and support advanced multimedia applications. The EWC will make its draft product specification available for public download and will provide implementation rights to all silicon suppliers and system vendors who join the organization. For details, visit www.enhancedwireless consortium.org

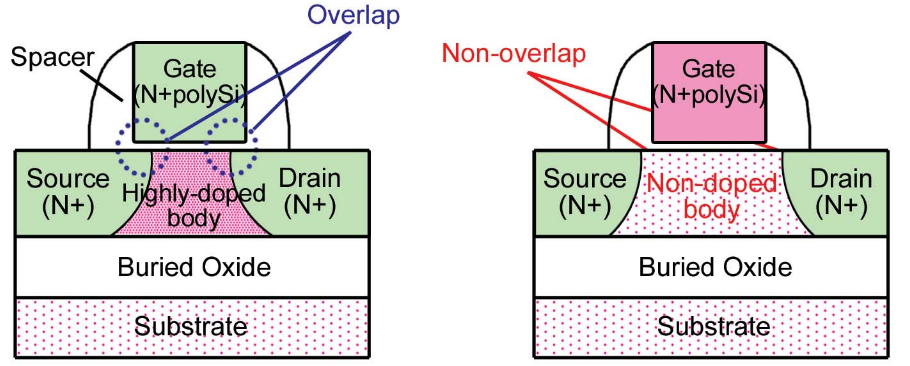
CIRCUITS AND DEVICES

TRANSISTOR REDUCES POWER CONSUMPTION BY 90 PERCENT

Oki Electric Industry Co., Ltd. (www.oki.com) recently announced the development of SOI (silicon on insulator) CMOS, a new device structure for super low off-leakage current. While maintaining the speed performance of previous devices, this transistor is said to reduce the standby consumption current (off-leak current) by over 90% compared to previous devices. Oki claims to be the first company in the world to develop a

■ TRANSISTOR STRUCTURE COMPARISON OF CONVENTIONAL SOI (LEFT) AND NON-DOPED BODY/NON-OVERLAPPED SOI (RIGHT).

PHOTO COURTESY OF OKI.



fully depleted SOI transistor using a non-doped body and non-overlap type SOI structure.

Two main achievements were cited by the company. First, in previous SOI devices, it was difficult to prevent current leakage, because the body potential rises unless the electrical potential of the body is fixed. By achieving a non-doped structure, Oki succeeded in reducing the current leakage. Second, with the previous source/drain to gate overlapped structure, parasitic capacitance occurred at overlap regions, which reduced the performance speed. By creating a non-overlap structure, Oki reduced parasitic capacitance and improved the device's speed.

While still in the experimental stage, the new technology is expected to facilitate the development of various products that rely on coin batteries and solar power.

■ HP'S NEW HDTVs FEATURE "WOBULATION" TECHNOLOGY FOR INCREASED DEFINITION.

PHOTO COURTESY OF HEWLETT-PACKARD.

NEW PROCESSOR TARGETS LOW-POWER APPS

ARM Ltd. (www.arm.com) has introduced the Cortex™-A8 processor, aimed at next-generation mobile devices. The A-8 delivers up to 2,000 Dhrystone MIPS, making it suitable for use in consumer products running multichannel video, audio, and gaming applications. Using less than 300 mW of power, the processor will run at more than 600 MHz in low-power 65-nm processes, with the core using less than 4 sq. mm of silicon (excluding NEON™ signal processing extensions, trace technology, and L2 cache). High-performance consumer designs will run the Cortex-A8 processor at up to 1 GHz in high-performance 90-nm and 65-nm processes. ARM says it has already secured five licensees for the processor, including Freescale, Matsushita, Samsung, and Texas Instruments, and future support from major EDA and operating system vendors.

HDTVS FEATURE HIGHER RESOLUTION

If you are playing Santa and have at least $1,600 to spend, you may want to look at the new line of television sets from Hewlett-Packard (www.hp.com). The company's new microdisplay high-definition TVs, which incorporate HP's patented "wobulation" technology, as well as some new LCD and plasma units, are shipping to major US electronics stores in time for the holidays. According to HP, its wobulation technology doubles the addressable resolution on the TVs, making it easy to view both native and compressed high-definition content from any source. Because the technology supports the format and frame rates for all TV programming, movies, or video, there is no limit to the kind of high-definition content viewers can access.

Based on the Texas Instruments DLP™ chipset, HP microdisplay TVs — including 50-inch (MD5020n), two 58-inch (MD5820n and MD5880n), and 65-inch (MD6580n) models — offer several other interesting features including a lighted front connectivity panel that allows up to 10 pieces of audio and video equipment to be connected without moving the TV. In addition, an on-screen menu shows thumbnail images of all input sources, eliminating the need to scroll through numerous inputs on the remote to find the right source. Four preset picture and four audio modes allow for simpler tuning. The microdisplay TVs also feature a 12,000:1 contrast ratio and a brighter lamp, so picture details emerge from dark or low-light scenes while colors appear richer. ■

INDUSTRY AND THE PROFESSION

AUTHORS GUILD SUES GOOGLE

The Authors Guild (www.authorsguild.org) and several authors recently filed a class action suit in federal court in Manhattan against Google over its unauthorized scanning and copying of books through its Google Library program. The suit alleges that the $90 billion search engine and advertising company is engaging in massive copyright infringement at the expense of the rights of individual writers. Apparently, Google has been reproducing works still under the protection of copyright, as well as public domain works from the collection of the University of Michigan's library.

"This is a plain and brazen violation of copyright law," said Authors Guild president Nick Taylor. "It's not up to Google or anyone other than the authors — the rightful owners of these copyrights — to decide whether and how their works will be copied." The individual plaintiffs are Herbert Mitgang, a former *New York Times* editorial writer and the author of numerous fiction and non-fiction books; Betty Miles, author of works for children and young adults; and Daniel Hoffman, the author and editor of many volumes of poetry, translation, and literary criticism. Hoffman was the Poet Laureate of the United States in 1973 and 1974. The Authors Guild represents more than 8,000 authors. The complaint seeks damages and an injunction to halt further infringements.

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Q&A

WHAT'S UP:

It's the holidays, where the days are short and there's plenty of time to build these one-night projects.

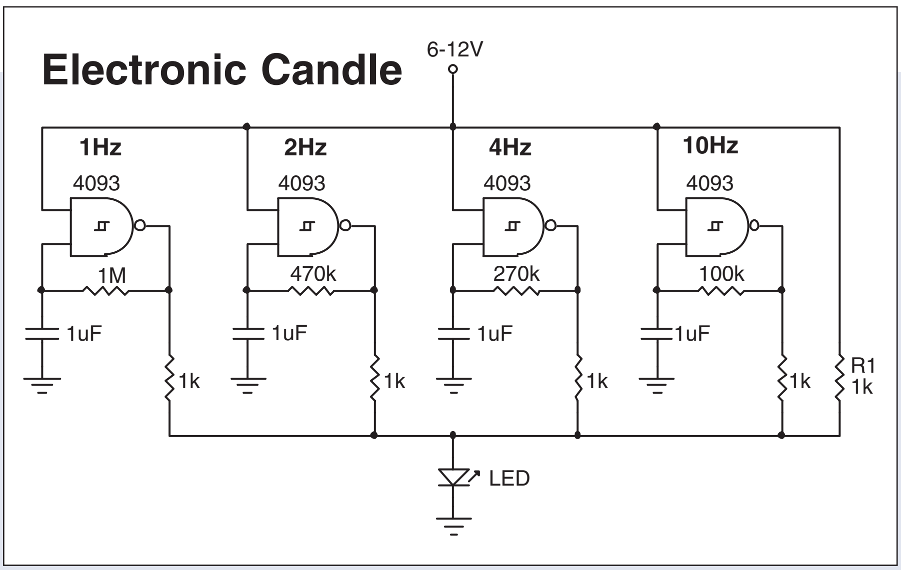
- ✔ Another round of Christmas candles,
- ✔ new chips for the auto applications,
- ✔ and two model RR must-haves.
- ✔ Also check out the books for nerds.

■ WITH TJ BYERS

In this column, I answer questions about all aspects of electronics, including computer hardware, software, circuits, electronic theory, troubleshooting, and anything else of interest to the hobbyist.

Fee free to participate with your questions, comments or suggestions.

You can reach me at:
TJBYERS@aol.com



■ FIGURE 1

CHRISTMAS CANDLES

Q I have just seen an electronic candle with flickering LEDs that looks very realistic. I would love to build my own version for Christmas. A schematic would be wonderful.

■ *Herb*

A Over the years, I've published a lot of different versions of flickering candles — always in the December issue. This year's candle is built around four square wave oscillators (Figure 1), each tuned to a different frequency. When the output of an oscillator goes high, it supplies current to the LED. (An LED is a current-controlled device where the brightness of the lamp is proportional to the current flowing through the diode.) When all oscillators are high, the LED is at its brightest because it receives current from all four sources. When all are low, no current flows through the oscillator resistors. R1 is used to bias the LED so that it glows softly when all the outputs are low.

This circuit is very versatile, in that you can easily set your rate of flicker from a breezy hallway to a calm bedroom scenario by simply changing the value of the feedback resistors (1M through 100K). If you find the flicker too harsh, add more oscillators in parallel — each with its own current resistor.

EXPERIMENTAL OPTICAL COMMUNICATIONS

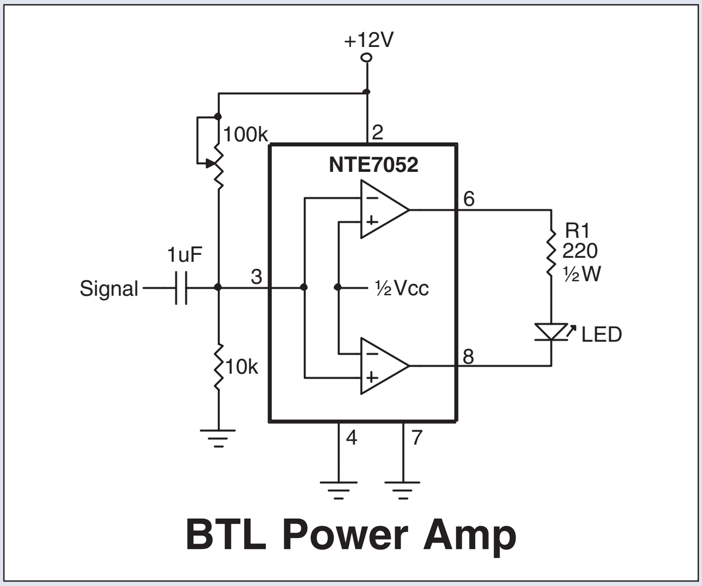
Q In reference to the "Garden Train Speed Control" in the Jul. 2005 issue, I wonder if I could use the smaller IPS021 to power an ultra-bright LED with a 0.5 amp rating? Next, how would one superimpose modulation on the LED for experimenting with optical communications?

■ *Ralph Cameron, Ottawa, Ontario*

A The IPS021 would work, but it's not the best choice. It was designed to drive inductive loads — like relays and solenoids — in harsh environments typically associated with auto electronics. The IPS021 input is engineered for a five-volt logic signal — the kind found in microcontrollers — which requires an analog converter for optical communications.

For your experiments, I'd use a pair of power amps in a bridge-tied load (BTL) output configuration — like the NTE7052 (Figure 2). The input signal connects to the inverting and noninverting inputs of the amplifier pair. With no input signal, both outputs are at 1/2 Vcc and no current flows through the LED. As the signal increases, the top output (pin 6) goes positive and the bottom output (pin 8) goes negative, causing current to flow through the LED in proportion to the input voltage. R1 sets the LED current using the formula R1 = (Vcc - LEDvoltage) / LEDcurrent — a 220-ohm resistor limits the current to about 50 mA. Make sure the wattage of the resistor is enough for the load using the formula Watts = Vcc x LEDcurrent. At currents above 300 mA, the IC may require a heatsink.

At low input signal settings, there will be a slight lag in the response time as the output voltage exceeds the forward voltage drop of the LED. To compensate, adjust the 100K pot until the LED just glows.



■ FIGURE 2

HEATER FAN CONTROLLER

Q I own a 1993 Chevy Astro van in which the heater control has quit working. I have done all the troubleshooting to discover the switch has become defective. I was hoping you would publish a PWM, or similar, circuit I could use to vary the speed of the 12 volt blower motor. Something simple yet elegant. Since I am high in the Colorado Rockies, I will really need the blower this winter.

■ *Ed Edmondson, Jr., Alamosa, CO*

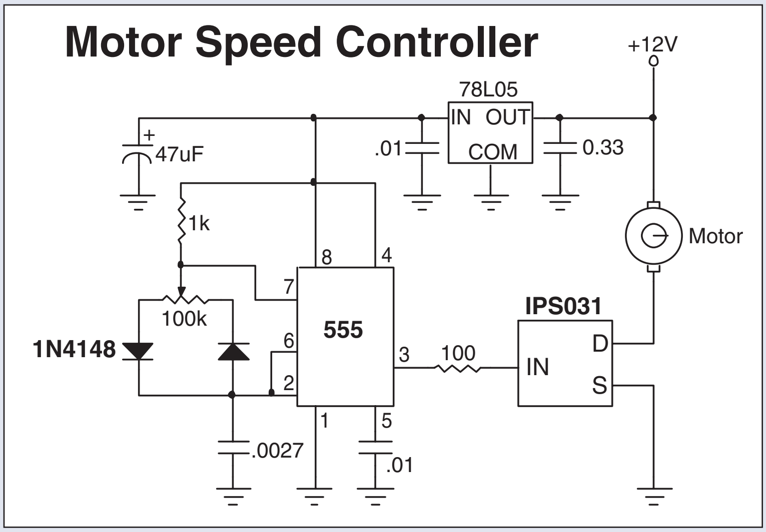
A The PWM circuit in Figure 3 should do the trick. It's a PWM built around a 555 timer that drives a IPS031 "Smart" FET. This module is specifically designed for auto applications like yours and requires no protection diode across the motor. The 1N4148 steering diodes allow a full range of speeds from 0 to 100%. When installing the controller, make sure that you get directly to the blower's hot lead — which means you may have to remove or bypass the blower resistor (**http://autorepair.about.com/library/illustrations/bl299a-lib.htm**). If the IPS031 keeps kicking out because of over current protection, replace it with an IPS0151.

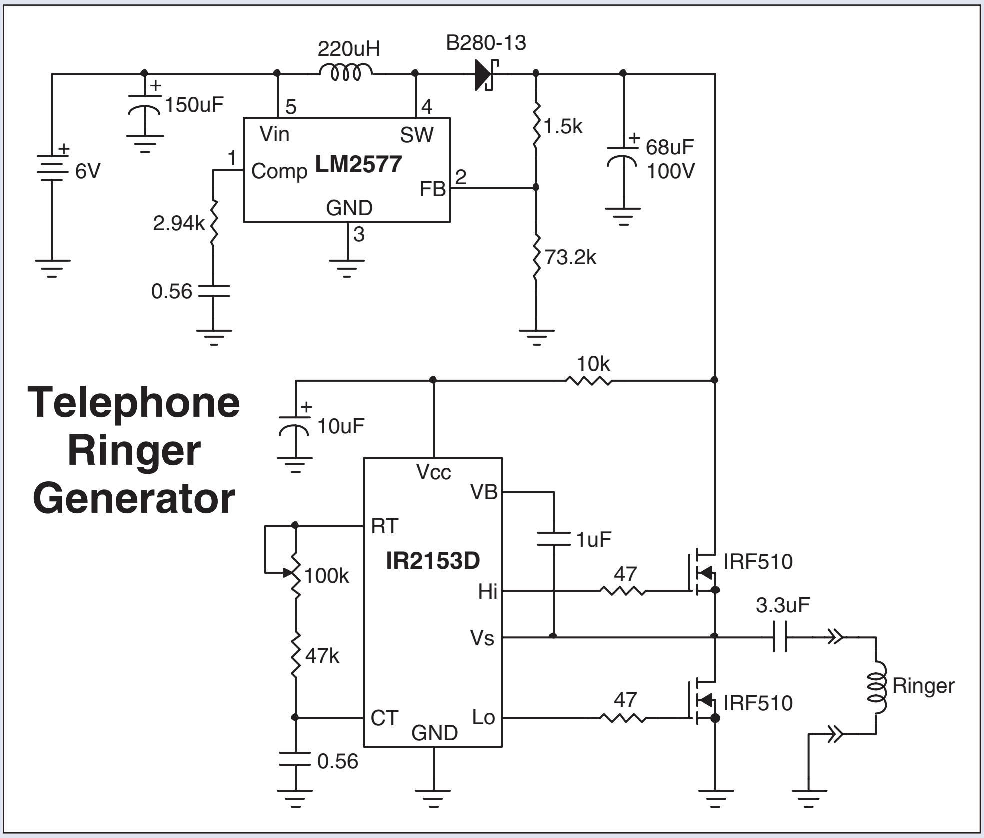
ANTIQUE PHONE RINGER

Q Last weekend, I went to an antique telephone show and ran across a collector with a tester clipped to his belt. I asked him what he had. He said it was a telephone ringer that was powered by (4) four AA cells. It produced a 20-Hz square wave of sufficient voltage to power a ringer. I asked him if he had a circuit, to which he said "in my head" and walked away. I am curious as to what he may have in that little black box.

■ *Joe Patay*

■ FIGURE 3





■ FIGURE 4

A The requirements for ringing a Ma Bell bell is an AC voltage of 40 to 150 volts at 20 Hz to 40 Hz. Lots of designs can do that, including a very simple DC-to-AC inverter with a step-up output transformer. The problem with most designs is that they are very inefficient. Want my take on it? I would first use a switching step-up converter to change six volts into 60 volts, then use a half bridge to create an alternating AC voltage — just like in Figure 4. The switching regulator is a robust LM2577 with a 60-volt output at 100 mA. That part of the circuit is straightforward.

The unique part of this design is the IR2153. Normally found in fluorescent ballast, the IR2153 contains a 555-type oscillator in addition to a half-bridge with a dead band of 1.2 us so that the two MOSFET transistors are never on at the same time. Instead of driving a fluorescent tube, though, I turned the chip around to switch 60 volts to the telephone ringer. The frequency of the switcher is set by the RC network across the RT and CT pins and can be fine tuned — via the 100K pot — to the resonant frequency of the bell.

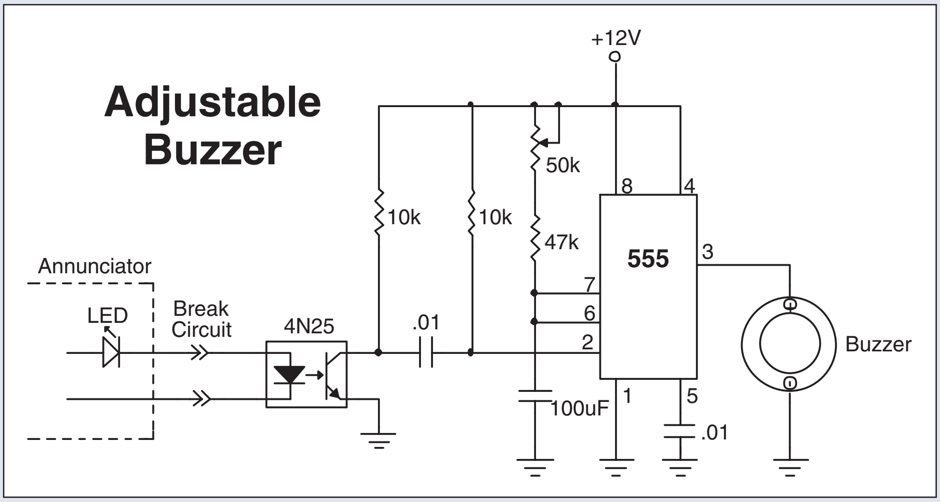
OPTOISOLATOR INTERFACE

Q In an annunciator application, each time a remote button is pressed, an LED goes on for about 20 seconds. During this time interval, I was asked to activate a medium level sound buzzer for about 10 seconds — adjustable by a pot. Can you please show a cheap and reliable circuit?

■ *Theodore Karatzas*
Electronics Engineer, Athens, Greece

A The 10-second buzzer tone is easily accomplished using a 555 one-shot monostable multivibrator and an off-the-shelf 12-volt piezo device. The values given in Figure 5 support a range from 5 to 11 seconds. Increasing the value of the 47K resistor lengthens the time the buzzer sounds; decreasing the 47K resistor shortens the time. The tricky part is inserting the 4N25's LED into your LED circuit. For this, you need to break the connection between the annunciator's LED and its power source. You can break it at any convenient point — either the top or bottom of the LED. Insert the 4N25 input to heal the break. In this way, the current that flows through the annunciator LED now flows through the 4N25 LED and turns on the transistor, which triggers the one-shot timer.

■ FIGURE 5



RR ROUNDHOUSE CONTROLLER

Q I need a circuit that will display a number on a seven-segment LCD between 0 and 9. The number

COOL WEBSITES!

The Flapper: The paper airplane that flaps its wings when it flies.

http://homepage.mac.com/keithgreenstein/Flapper/PhotoAlbum41.html

59 Optical Illusions and Visual Phenomena.

www.michaelbach.de/ot/

Globetrotting — a collection of interesting satellite maps; includes Area 51.

http://googleglobetrotting.com

STOCKING STUFFERS

Need a gift for that electronic nerd in your life? Books are always a safe choice. Here are two that I find informative and interesting.

The first is *The Digital I/O Handbook* by Jon Titus and Tom O'Hanlan. The book talks about digital inputs and outputs in just about every situation the experimenter is likely to encounter, including circuit isolation and working with high voltages. Chapter 4 deals with sensors — including Hall-effect, photoelectric, and digital encoders. This easy-to-read book is available from Amazon.com

The second is *USB Complete, Third Edition* by Jan Axelson. The book is touted as "Everything you need to develop custom USB peripherals." In this book, Jan shows how to design and program devices that use USB to communicate with PCs, and describes Visual Basic routines. New to this edition is a chapter on USB On-The-Go — a dual role device that can function both as a limited-capacity host and as a USB peripheral. Jan's books are available from the *Nuts & Volts* Bookstore (www.nutsvolts.com/Store_Pages/Books/Index.htm); an Adobe download version is available from Amazon.com

represents which track on my HO scale train roundhouse has power to it. As I turn a single pole 10-position rotary switch, I want the LCD to indicate which track is live. The track runs on AC power and the voltage varies from 0 to about 13 volts.

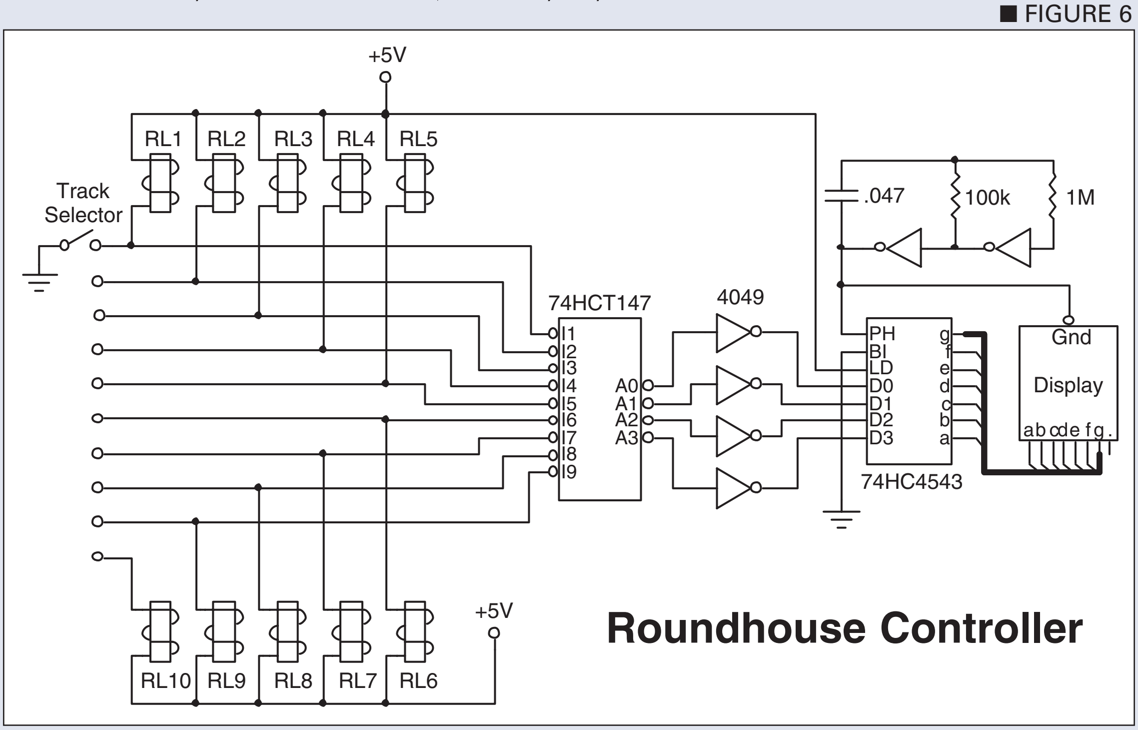
■ *Greg Harris*

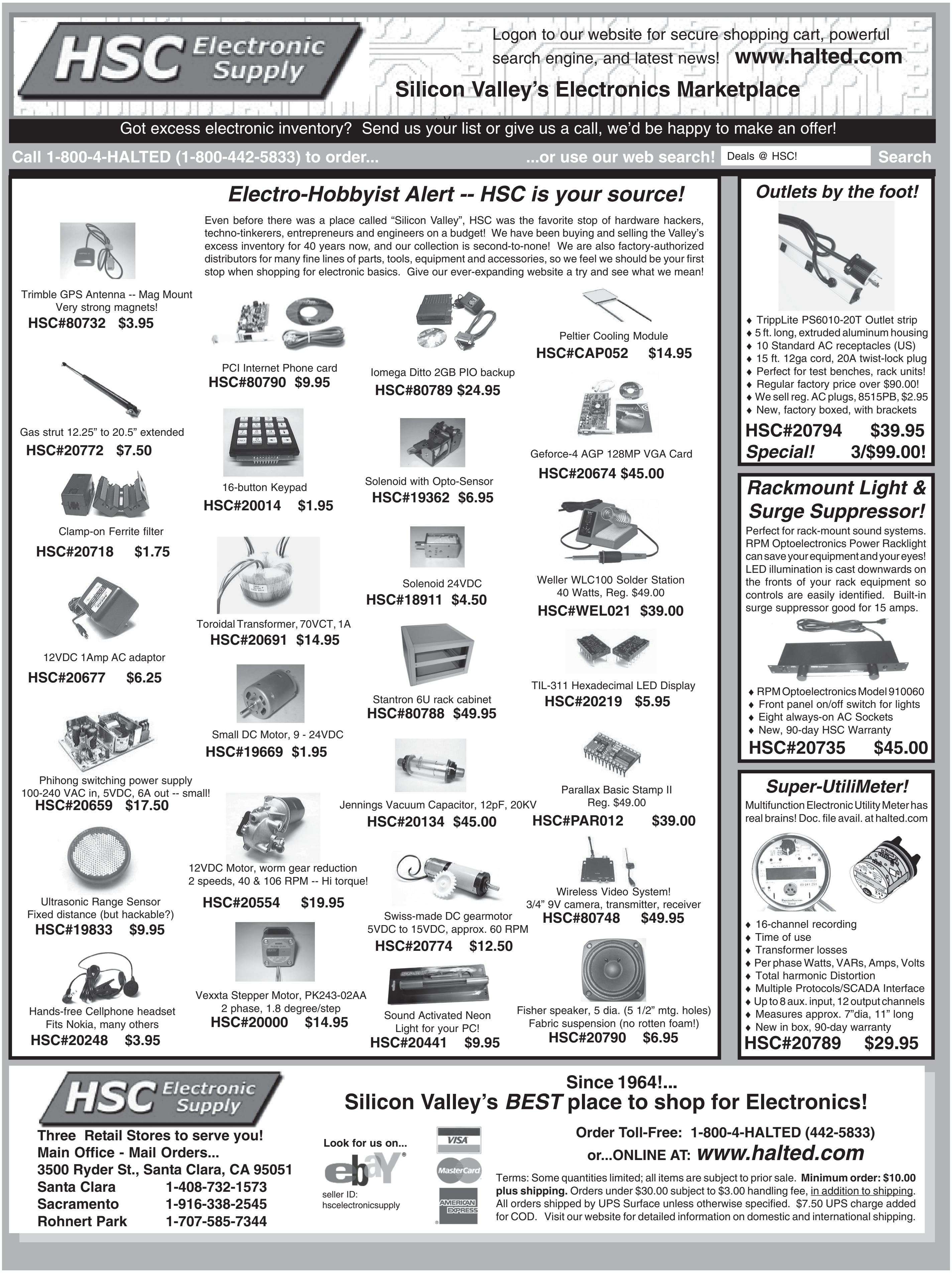
A At first I thought of adding a digital pulse atop the AC that would indicate the active track. But then I remembered DCC (Digital Command Control). DCC allows more than one locomotive to share the same track — each with different speeds - and it uses digital pulses. Which means there could be a conflict. I know your setup doesn't have DCC — but someday you might want it. So the only solution I can see is to use the rotary switch to activate relays — relays that activate the selected track — and decode the hot track from the voltage applied to the relay coil (Figure 6).

The design requires a 10-to-4 encoder (for the rotary switch), an inverter, and a BCD-to-seven-segment decoder. Whew, that's a mouthful of digi-talk. It means, we connect each relay to a separate input of a 10-to-4 encoder — which changes it to a BCD code. The 74HCT147 performs the decimal-to-BCD translation. From here, a seven-segment LCD driver — a 74HC4543 — displays a number that represents the active track.

Unfortunately, the logic is backwards for the 74HC4543 inputs — so an inverter is needed. I decided on a hex 4049 because it allows me to generate a square wave (via the two leftover gates) that's needed for the LCD display. As for the relays, make sure they can handle the voltage and amps you need to feed the roundhouse. I don't think a reverse diode (1N4001) across the relay coil is needed — the input of the 74HCT147 is diode protected — but it might be a good idea to include one anyway. ■

■ FIGURE 6

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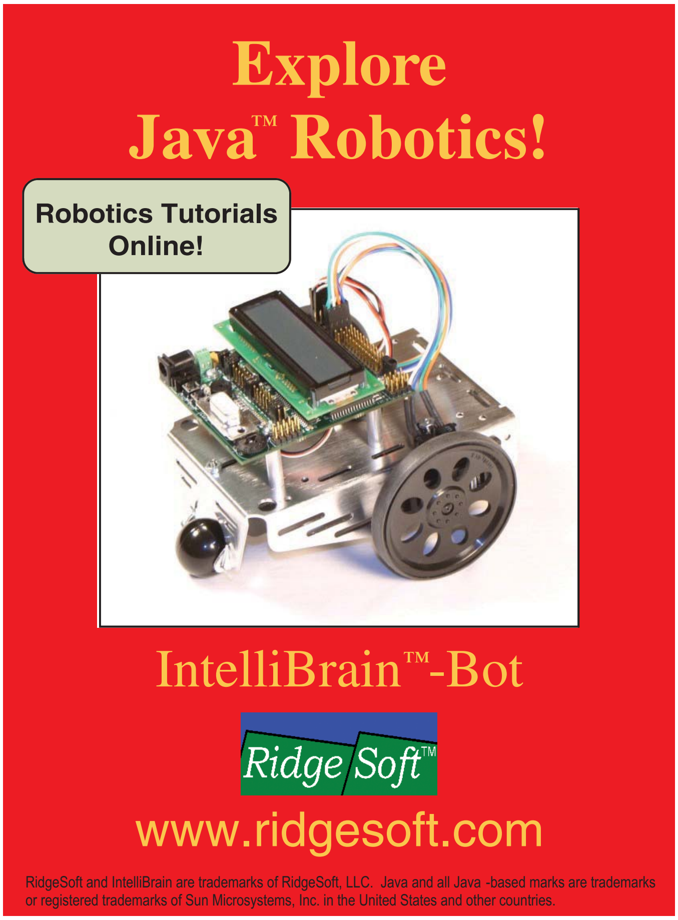
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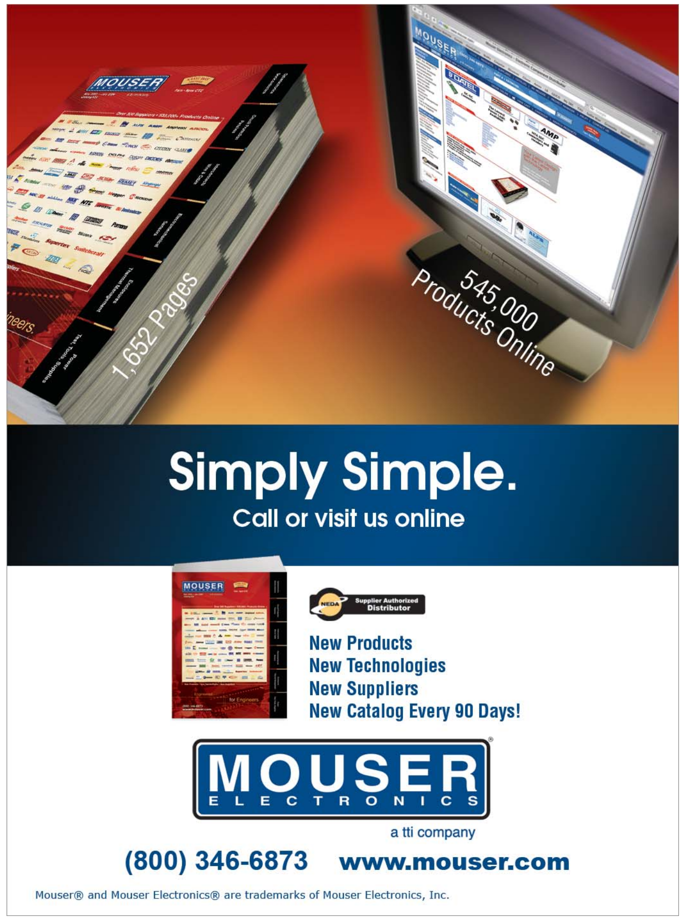
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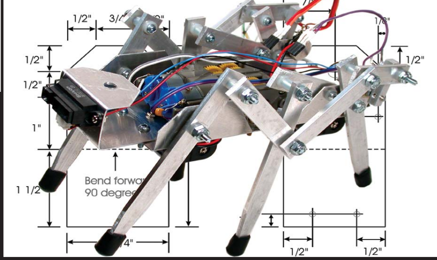


■ GUEST HOSTED BY DAVE PROCHNOW

ME AND MINI ME

How to Transplant the "Brain" of Robosapien into a Mini Robosapien, Bwaa-Ha-Ha

GOSH, IT'S TOUGH BEING A MAD SCIENTIST THESE DAYS. There are no good secret agents left to torment (Bond, who?), you can buy lasers at virtually any strip mall, and everybody's far too busy for world domination. So what's an evildoer to do?

■ ALL YOU NEED IN ORDER TO BECOME THIS TYPE OF MAD SCIENTIST IS A ROBOSAPIEN AND A MINI ROBOSAPIEN. THE MAIN CIRCUIT BOARD "BRAIN" WILL BE TRANSPLANTED FROM THE ROBOSAPIEN INTO THE MINI ROBOSAPIEN.

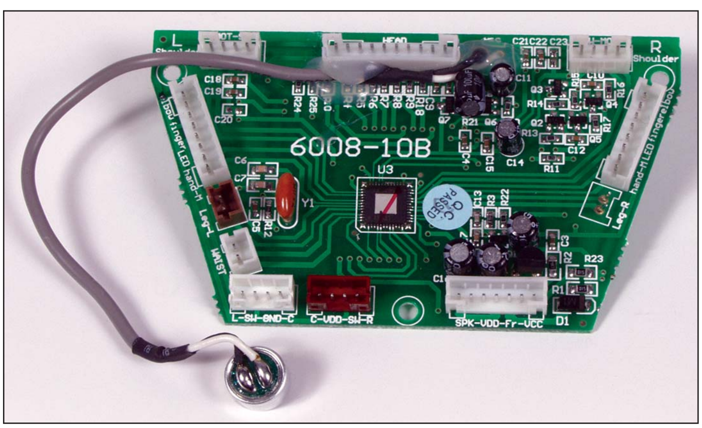
You must choose your diabolical projects very carefully. Brain transplants have always been a real crowd pleaser. Now where can you find a sophisticated brain that can be readily plucked from a perfectly healthy specimen and squeezed inside an innate dumb head?

Well, if it's a brain you're after, look no further than the best-selling robot of all time — Robosapien from WowWee Robotics. Embedded within an engineering masterpiece of motors, springs, sensors, and several pounds of ooey-gooey lubricant is a beautiful brain. Designed by the world-renowned Mark W. Tilden (a respected mad scientist in his own right), the Robosapien brain is capable of being easily transplanted into virtually any type of robot, vehicle, or toy. In fact, you can obtain a pretty good education in robot brain design, function, and integration by studying Tilden's marvelous cranial creation.

Now, with brain in hand, a suitable victim, er, subject must be found. How about a robot that is generally perceived by the public as being a laughable novelty — a robot that has no brain, only one motor, and no speaker? That's it! Let's take a Mini Robosapien and integrate the brain from Robosapien into its younger, smaller sibling. This is truly an evil hack that will result in a Mini Robosapien that can be controlled with an IR remote control — a real Mini Me.

NOW THIS WON'T HURT A BIT

The first step in any good brain transplantation project is to remove the brain without damaging it. Can you say, "Abby Normal"? A fair warning: Disassembling a Robosapien is not the type of project for either the technically challenged or the pocketbook-challenged. But, before you get your underwear in a bunch, there *is* a superb source for Robosapien hacking information and instruction. It's the blockbuster book, *The Official Robosapien Hacker's*



■ HOUSED INSIDE THE CHEST CAVITY OF THE ROBOSAPIEN, THIS MAIN CIRCUIT BOARD IS THE "BRAIN" THAT DRIVES THIS ROBOT. YOU SHOULD REMEMBER WHERE EVERYTHING GOES, THOUGH WOWWEE ROBOTICS AND MARK TILDEN HAVE MADE ROBOSAPIEN AN EASY ROBOT TO HACK BY LABELING EVERY PIN ON THE MAIN CIRCUIT BOARD "BRAIN." NOTE: THIS PARTICULAR BRAIN HAS BEEN "OVER CLOCKED" WITH A HIGHER FREQUENCY CRYSTAL AT Y1. REFER TO *THE OFFICIAL ROBOSAPIEN HACKER'S GUIDE* FOR MORE INFO ON THIS TYPE OF HACK.

Guide (McGraw-Hill, 2005). I should know what I'm talking about; I wrote the book on Robosapien hacking — literally.

Inside this book you will learn how to locate the Robosapien brain (by putting it on its back), how to identify all of the various motor, sensor, power, microphone, and speaker receptacles, and the step-by-step procedure for safely removing the brain from the body cavity. I don't want to leave you in the lurch, however, so here is the *Reader's Digest* version of Robotomy 101.

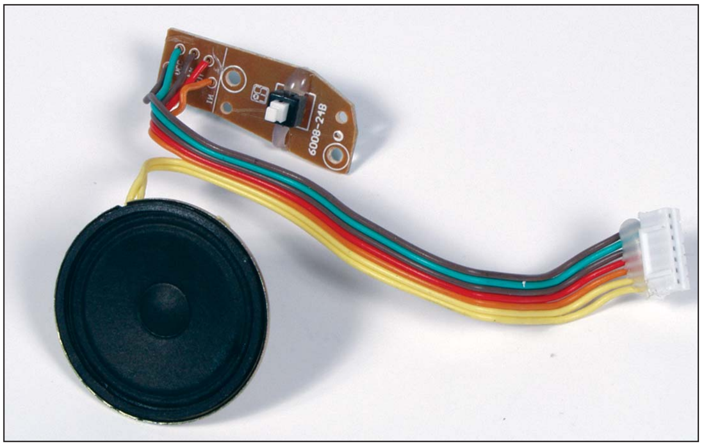
Begin your brain surgery by removing the main Robosapien body screws with a trusty No. 0 Philips screwdriver. Now the real fun begins — dismemberment and disembowelment. Don't be alarmed, but some of this surgery is, ahh, destructive. You must be willing to crush the back of the Robosapien's skull, drill holes in the back of its hips, sever each of its ears, and snip a few wires here and there. Consider this operation to be the perfect opportunity to release your inner evil genius. Bwaa-ha-ha.

During this brain removal operation, try to salvage as many Robosapien components as possible. Consider this list of "must have" body parts:

Speaker/Power Switch — The first item you remove from Robosapien is the plug for this assembly, which is located on the back body cavity plate. Then, you can safely set the back body cavity plate with the attached speaker and power switch aside while you continue your body part harvesting. While the power switch harness is easy to unscrew from the body plate, the speaker removal can be a little tricky. Yes, there are three screws that hold the speaker cover in place, but the speaker is actually glued to the plastic. Luckily, this is a simple elastic-type of glue. Therefore, a small knife blade or thin, flat screwdriver can easily and safely pry the speaker out of the plastic body plate. Thanks WowWee.

IR Detector/LED Array — Housed inside the Robosapien helmet, this assembly is a vital communication link between the brain and the original Robosapien IR remote control. Get ready; this isn't going to be pretty.

First, you have to cut the ears off of the side of the helmet. Sometimes this process will expose the small screw that is actually holding the helmet and visor on the Robosapien head. In this case, just unscrew each ear and slip the helmet and visor off. If your cutting and bending is a little more forceful, you might remove the ear *plus* this screw all in one big snip. Either way, after the helmet and visor have been removed, you must cut the purple plastic cover off the back of the Robosapien head. After cutting open *many* Robosapiens, I've learned that a good pair of sharp pliers can pinch this cover off cleanly and efficiently. Now, it's a simple process of splitting the remaining helmet in two, snapping the neck gear in half, and fishing the main circuit board plug up through the chest gearbox.

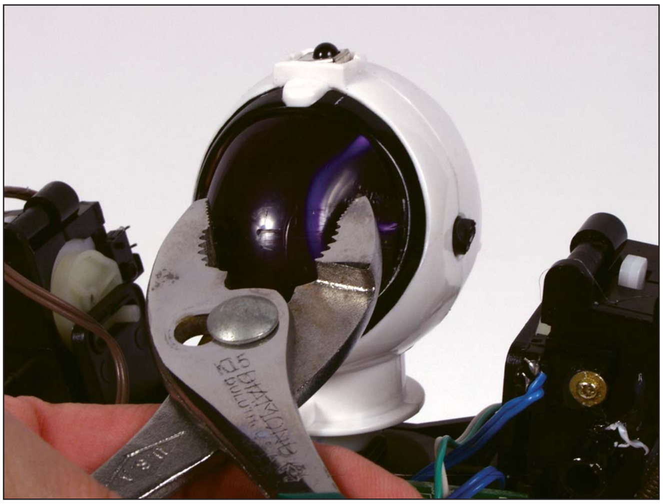


■ SAVE THE SPEAKER/POWER SUPPLY HARNESS FOR LATER IMPLANT INSIDE THE MINI ROBOSAPIEN.

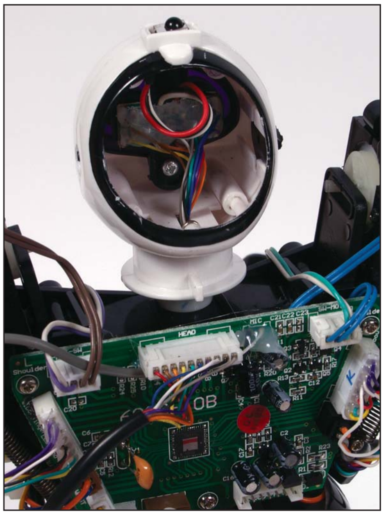
Motor(s) Plug(s) — There are leg, waist, shoulder, elbow, and wrist motors, each embedded in a fancy gearbox. If you plan on using your own motors (as we are going to do in this hack), then you can just cut or desolder the motor leads and save the associated plugs.

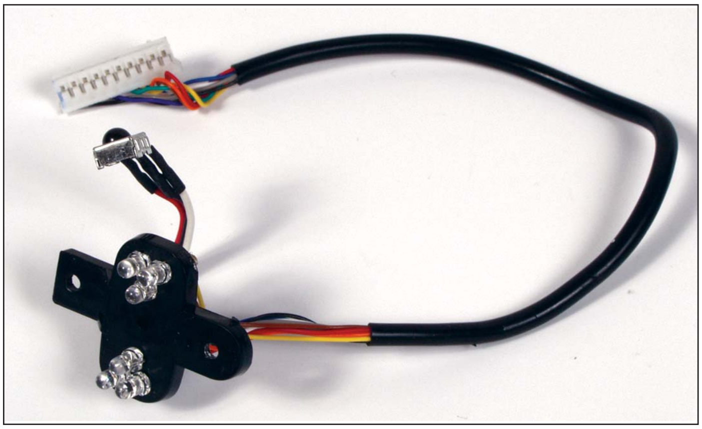
Microphone — Also known as the sound sensor, the microphone has been slipped inside a holder on the front of the chest gearbox. This is a good sensor to save for future brain transplants. Likewise, if you feel mechanically inclined, you can add

■ ONE (OR THREE) GOOD SQUEEZE(S) ON THE PURPLE PLASTIC THAT IS LOCATED ON THE BACK OF THE ROBOSAPIEN HEAD WILL GIVE YOU ACCESS TO THE IR DETECTOR AND LED "EYE" ARRAY.



■ UNSCREW THE LED ARRAY AND CAREFULLY SPLIT THE REMAINING HELMET IN HALF TO REMOVE THE IR DETECTOR. A GOOD PAIR OF DIAGONAL CUTTERS WILL BE NECESSARY FOR CUTTING THE NECK GEAR IN HALF.





■ THIS IS YOUR TICKET TO COMPLETE MINI ROBOSAPIEN CONTROL VIA IR. BEFORE YOU CAN RIDE WITH THIS TICKET, HOWEVER, YOU WILL HAVE TO FIRST SNAKE THE IR DETECTOR/LED ARRAY CONNECTOR OUT THROUGH THE CHEST GEARBOX.

one or more of the six touch sensors to this body part list.

Battery Pack Connectors — All the way down inside each foot are two battery compartment connectors. These four wires should be desoldered from each battery compartment lug. Make sure that you retain the capacitor that is attached to the right foot's main power line (the red wire).

Now, with all the body parts at hand, connect each plug to the properly labeled main circuit board connector. Each plug is keyed to its respective connector and three of the potentially confusing plugs are color-coded. You will also find clear and understandable labels silkscreened on the main circuit board that identify the exact function of each receptacle. Again, thanks, Mark Tilden.

PLEASE, BE PATIENT

Set this brain aside and prepare the recipient for a mind-altering experience. In order to demonstrate the hidden power that is contained within the Robosapien brain, we selected the lower cost Mini Robosapien (under $10) as our Guinea pig, er, patient.

■ REMOVE THESE SIX SCREWS TO GAIN ACCESS TO MINI ROBOSAPIEN'S INNARDS.

In order to gain access to the Mini Robosapien's inner workings, you must remove six screws. Two of these screws are hidden underneath the battery compartment cover.

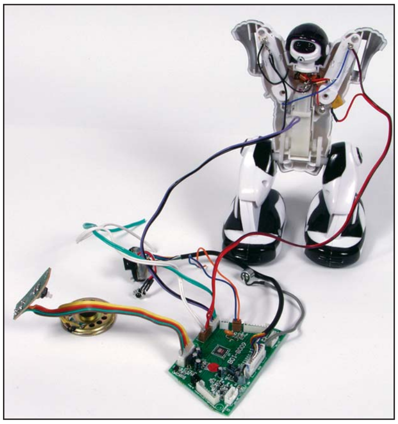
Inside the Mini Robosapien, there are only six connections that must be made between the brain and patient. Four of these connections are power supply-related, while the other two are controls for the Mini Robosapien's single motor.

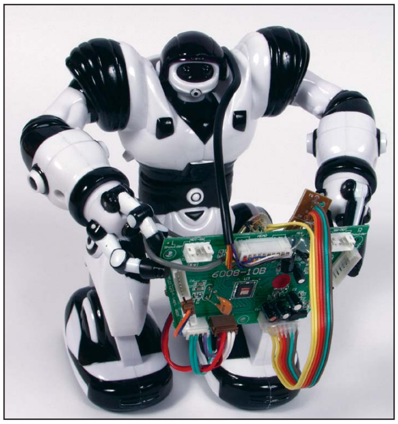
Since every mad scientist is a control freak, we must exert complete control over the Mini Robosapien with the IR remote control. Therefore, you should desolder the single motor connection from the Mini Robosapien's power switch and, instead, attach a connection from one of the brain's motor control receptacles to this motor. I prefer to use the Robosapien left leg motor receptacle. The result should be that a key press on the IR remote control for FORWARD will drive the Mini Robosapien forward. I recommend testing this process before you button up your patient and take your mad creation out of the laboratory.

IT'S ALIVE!

Before your Mini Robosapien will be able to pillage your local neighborhood and strike fear into the hearts of the townspeople, you might have to provide a more robust power supply. The Mini Robosapien's standard two AAA-size batteries aren't going to take your brain transplant very far. Luckily, though, you have only one motor to power. I have found that the Mini Robosapien's battery pack will provide about one hour's worth of horror on these two batteries. So get out there and create some mayhem. Bwaa-ha-ha. ■

■ ALL WIRED UP FOR TRANSPLANT TESTING. AND GUESS WHAT – IT WORKED!





■ I MAY BE MAD, BUT I KNOW BEAUTY — AND THIS BEAUTY IS MORE THAN SKIN DEEP. ACTUALLY, THIS CONTRAPTION MAKES A GREAT TESTBED FOR EXPLORING VARIOUS APPLICATIONS FOR THE ROBOSAPIEN BRAIN. PLUS, IT'S A GREAT BEGINNING FOR WORLD DOMINATION. BWAA-HA-HA.

Dave Prochnow is a frequent contributor to Nuts & Volts and SERVO Magazine, as well as the author of 25 nonfiction books, including the mega-hit The Official Robosapien Hacker's Guide (McGraw-Hill, 2005). You can learn more about this Robosapien book and other robotics/electronics projects on Dave's website: ***www.pco2go.com***

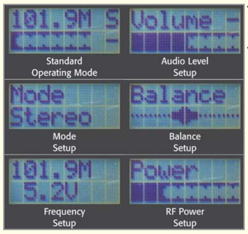
FM Broadcasters

Fun Stuff For The Holidays!

Digital FM Stereo Transmitters

- ✔ **Rock stable PLL synthesized**
- ✔ **Front panel digital control and display of all parameters!**
- ✔ **Professional metal case**
- ✔ **Super audio quality!**
- ✔ **25mW and 1W models!**

For nearly a decade we've been the leader in hobbyist FM radio transmitters. Now for 2005 we introduce our brand new FM30 series of FM Stereo Transmitters! We told our engineers we wanted a new technology transmitter that would provide FM100 series quality without the advanced mixer features. They took it as a challenge and designed not one, but TWO transmitters!



The FM30 is designed using through-hole technology and components and is available only as a do-it-yourself kit, with a 25mW output very similar to our FM25 series. Then the engineers redesigned their brand-new design using surface mount technology (SMT) for a very special factory assembled and tested FM35WT version, with 1W output for our export market! Both are designed around an RF tight vinyl clad metal enclosure for noise free and interference free operation. All settings are done through the front panel digital control and LCD display! All settings are stored in non-volatile memory for future use.

Both the FM30 and FM35WT operate on 13.8 to 16VDC and include a 15VDC plug-in power supply. The stylish metal case measures 5.55"W x 6.45"D x 1.5"H and is available in either white or black. *(Note: The end user is responsible for complying with all FCC rules & regulations within the US, or any regulations of their respective governing body).*

FM30	**Digital FM Stereo Transmitter Kit, 0-25mW White**	**$199.95**
FM30B	**Digital FM Stereo Transmitter Kit, 0-25mW, Black**	**$199.95**
FM35WT	**Digital FM Stereo Transmitter, Assembled, 1W, White**	**$299.95**
FM35BWT	**Digital FM Stereo Transmitter, Assembled, 1W, Black**	**$299.95**

Professional Synthesized Stereo FM Transmitter

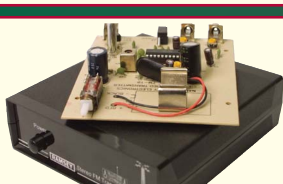
- ✔ **Fully synthesized 88-108 MHz for no frequency drift**
- ✔ **Line level inputs and output**
- ✔ **All new design using SMT technology**

Need professional quality features but can't justify the cost of a commercial FM exciter? The FM25B is the answer!

A cut above the rest, the FM25B features a PIC microprocessor for easy frequency programming without the need for look-up tables or complicated formulas! The transmit frequency is easily set using DIP switches; no need for tuning coils or "tweaking" to work with today's "digital" receivers. Frequency drift is a thing of the past with PLL control making your signal rock solid all the time - just like commercial stations. Kit comes complete with case set, whip antenna, 120 VAC power adapter, 1/8" Stereo to RCA patch cable, easy assembly instructions, and the SMT parts are factory preassembled - you'll be on the air quick!

FM25B	**Professional Synthesized FM Stereo Transmitter Kit**	**$139.95**

Tunable FM Stereo Transmitter



- ✔ **Tunable throughout the FM band, 88-108 MHz**
- ✔ **Settable pre-emphasis 50 or 75 µSec for worldwide operation**
- ✔ **Line level inputs with RCA connectors**

The FM10C has plenty of power to cover your home, back yard, or city block. You'll be amazed at the exceptional audio quality of the FM10C. Tunes through the entire 88-108MHz band. Re-broadcast your favorite music commercial free and with the dynamic range the musician intended, without all that nasty compression the big boys use to make their station sound louder than the competition. Compression produces a noticeably muddier and less dynamic sound. Runs on an internal 9VDC battery, external 5-15VDC, or our FMAC AC power adapter.

FM10C	**Tunable FM Stereo Transmitter Kit**	**$44.95**
FMAC	**110VAC Power Supply for FM10C**	**$9.95**

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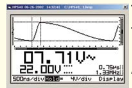
Get the brand new 2006 Ramsey Hobby Catalog! ***96 value packed pages*** of the neatest goodies around! Order your copy on-line or give us a call!

Hand Held Digital Scope With DVM Readout

- ✔ **Digital waveform and measurement display!**
- ✔ **10MHz and 40MHz sample rates!**
- ✔ **Backlit LCD display**
- ✔ **RS232 output (40MHz model only)**
- ✔ **Charger, case, probes included**

We've seen a lot of portable scopes and scope/meters, and we've also seen the price tags! They have always been way out of the reach and budget of the hobbyist. No more! Now for close to the price of a good DMM you can have a personal scope that also has DVM readout for dBm, dBV, DC, and True RMS! Frequency readout is also displayed on the screen through markers, plus the scopes have two memories for digital storage.



The 40MHz model also includes an RS232 output and serial interface to capture the screen display on your scope to your PC at the mere push of a button! These scopes run on 5 standard AA Alkaline batteries (not included) which provide up to 20 hours of use. You can also use rechargable AA NiMH batteries instead and they'll be charged with the optional power supply. Both units come with a custom foam lined high impact carrying case, set of high quality scope probes, AC power adapter and a comprehensive user's manual. If you're working with electronic circuits, automotive applications, audio and stereo applications or other applications, the personal scope is for you...at a price that can't be beat!

HPS10SE	**Personal Handheld 10MHz Digital Scope**	**$229.95**
HPS40	**Personal Handheld 40MHz Digital Scope w/RS232**	**$299.95**

Audio/RF DDS Signal Generator

- ✔ **DDS and SMT technology!**
- ✔ **Frequency range 0 Hz to 5 MHz with 0.1Hz resolution!**
- ✔ **0 to 10V peak to peak output level**
- ✔ **Sine, Square, or Triangle waveform output!**
- ✔ **Non-volatile memory**
- ✔ **Factory assembled and tested**

DC to 5 MHz...In 0.1 Hz Steps!

Following in the footsteps of our world famous SG550, we are proud to introduce the SG560, the next generation signal generator!

To begin with we increased the frequency range all the way up to 5MHz and all the way down to 0Hz (yes, we mean zero...or DC!) in continuous 0.1Hz steps across the entire range! Then we gave it a variable output level all the way up to 10V peak to peak in either Sine, Square, or Triangle waveforms! You can also provide a DC offset to the output to recreate TTL, 4000 series logic levels, low voltage logic levels, AC waveforms with a DC component, or just plain AC signals!

The SG560 contains a 10 bit DDS and filtering for a low noise, accurate low distortion output. The output stage utilizes the latest technology in digital modems and high power, high bandwidth DSL modems and is capable of a direct output of 2.5W! You can even generate carrier signals in the AM band for testing AM receivers and circuits. A jumper option for zero ohm output impedance allows for true output terminal metering. But watch out, 2.5 watts is enough to damage incorrectly connected circuits!

Surface mount technology is used throughout the SG560 making it extremely reliable and accurate. Frequency is entered directly on the sealed membrane keyboard and adjusted with a precision rotary encoder with an oversized knob. Both frequency and output level are displayed on a high contrast, two-line LCD display.

The SG560 operates on 8 to 16VDC and includes a standard 110VAC power adapter. Because of the surface mount design the SG560 is only available factory wired and tested. If you are looking for a lab quality signal generator at a super price, the new generation SG560 fits the bill... and a whole lot more!

SG560WT	**Audio/RF Signal Generator, Factory Assembled**	**$329.95**

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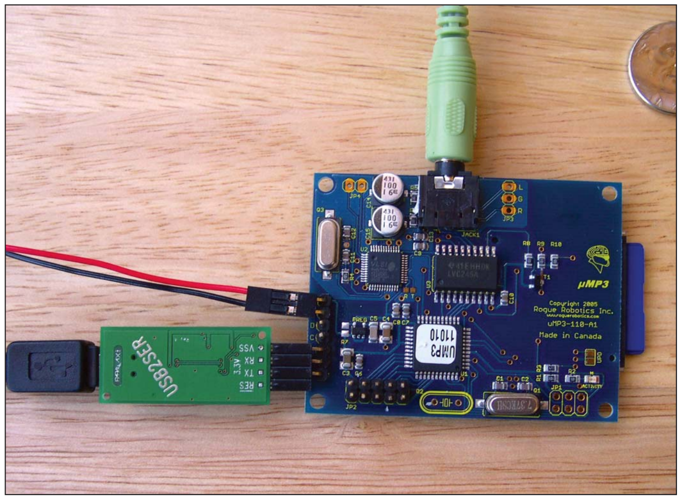
■ BY JON WILLIAMS

THE SOUNDS OF THE SEASON

Wow, can you believe we're at the end of the year already? Another one gone by so quickly. But it's easy to tell — decorations are everywhere, the crowds in the malls are growing larger every day, and the sound of music is in the air. (Boy, that last bit was cheesy, wasn't it?) Have you ever noticed that? This time of year music seems to be playing everywhere. Seasonal music, of course — I guess there's just more of it for this particular season. So, let's go with the seasonal flow, shall we? Let's build a digital music player to compliment the holiday decorating we've done around the house.



■ FIGURE1: uMP3 VIA USB2SER

A few months ago, one of my Texas prop building friends — an exuberant guy named Vern Graner — told me about a cool MP3 player module from Rogue Robotics called the uMP3 (micro MP3) that was BASIC Stamp compatible. It turns out that Vern is right: the uMP3 player is cool, it is BASIC Stamp compatible, and thanks to recent efforts at Rogue Robotics, it's even easier to use with BASIC Stamps — including the Prop-1 controller.

Now, before we get into this let me start telling you that the program we're going to work with here requires the uMP3 to be running firmware 110.11 or later. You can get this from Rogue Robotics and update the uMP3 player through a serial port. Make sure that you do this before you connect it to your BASIC Stamp module.

LET THERE BE MUSIC

The uMP3 player has a lot of interesting features, but for the sake of this month's project we're going to keep things simple. What we're going to do is randomly play one of the songs on the player, and won't repeat a song until all have been played. While the program is neat and straightforward, it has a couple tricks inside that will be useful in other projects.

UMP3 SETUP

Before we connect the uMP3 player to the BASIC Stamp, we need to configure it with a terminal program. Once we've adjusted the settings to our liking, they're non-volatile, and we don't have to worry about making them again unless we update the firmware (which clears all user settings to default values).

The uMP3 has TTL level serial connections so I used the Parallax USB2SER module to connect the uMP3 player to my PC. The photo in Figure 1 shows the USB2SER connected to the uMP3. Note the upside-down orientation of the USB2SER so that it matches the uMP3 connections. And just a comment on the photos: my unit was originally a 111.10 version (hence the label) and didn't have header pins; I added those myself. Later versions include header pins installed by Rogue, so they may look different than mine.

Using a terminal program, we can check the firmware and update the settings to make things operate smoothly with the BASIC Stamp. Figure 2 shows a HyperTerminal session with the uMP3. Out of the box, the uMP3 is configured for 9600 baud so that's what the terminal was set for. At power-up, the uMP3 scans the connected media (SD card) and, when ready, it will

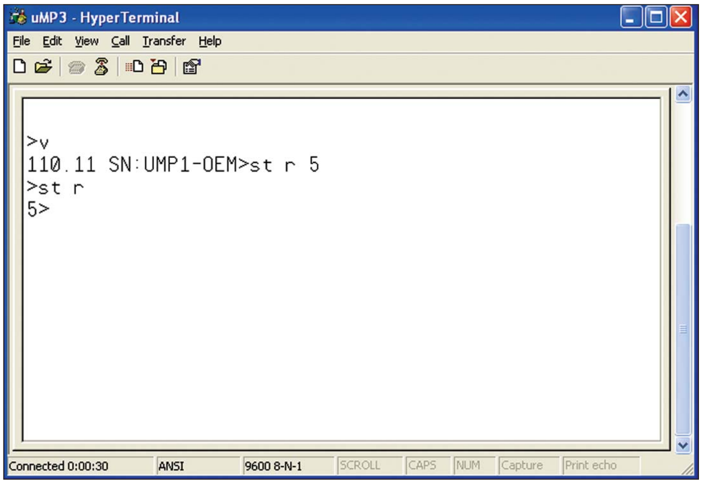
transmit a ">" to the terminal.

We can check the firmware version with the "v" (no quotes) command. Note that all uMP3 commands are terminated with a carriage return, and we especially have to remember this for our BASIC Stamp program. As you can see, I have the version (110.11) that supports a feature we need (prompt delay).

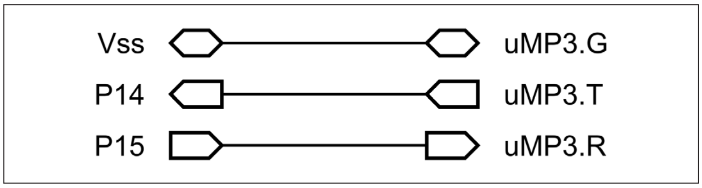
Before connecting to the BASIC Stamp, we want to change the prompt delay to five milliseconds. This will let the **SERIN** instruction load and get ready after a command is sent to the uMP3 with **SEROUT** — that way we can catch any response and use it. Change the prompt delay with "st r 5" and then confirm the setting entering "st r" without a delay time. The current delay will be reported before the prompt character (it should be 5).

Okay, now we're ready to get going. Connecting to the uMP3 player falls into the "no-brainer" category — just two wires for serial (TX and RX) and a common ground (I used a cable hacked from a long-dead servo). Remember that the uMP3 player uses TTL level signals, so it's Stamp-compatible without any interfacing.

Figure 3 show the electrical connections between the Stamp and the uMP3, and the photo in Figure 4 shows the player and everything plugged in. Since the output is low level (i.e., for headphones), I connected a set of low-cost amplified computer speakers (green plug). Of course, you'll have to provide (regulated) five volts to the uMP3, as well. If you're experimenting with a BOE or PDB, you can pull power from it.



■ FIGURE 2: uMP3 SETUP



■ FIGURE 3: uMP3 CONNECTIONS

PLAY IT AGAIN ... BUT NOT UNTIL I'VE HEARD 'EM ALL

The purpose of our program this month is to play MP3 files — perhaps background music as we're having holiday dinner with friends and family. Let's make it fun, though; let's make it behave like a CD player in "shuffle" mode and force it to play all songs on the list before repeating. Before we attempt to play any of the songs on the uMP3, we need to make sure we're actually connected to it. Here's the Reset section:

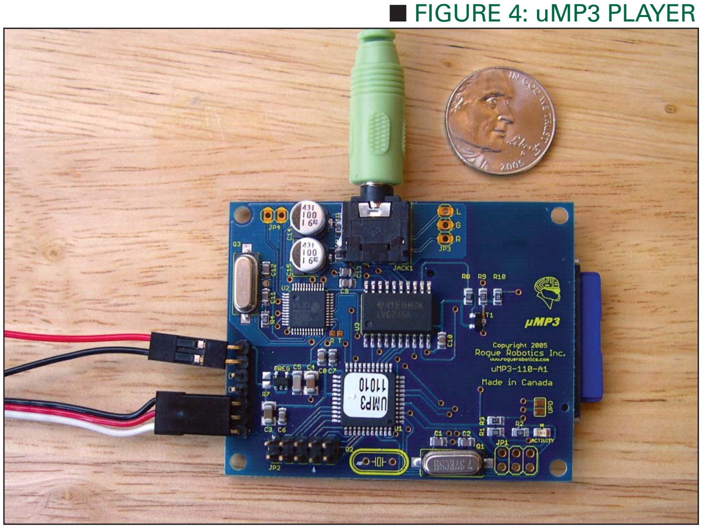
```
Reset:
  PAUSE 2000
  SEROUT TX, Baud, [CR]
  SERIN  RX, Baud, 250, Reset, [WAIT(">")]

  lottery = 1225
  GOSUB Reset_Markers
```

At start-up we wait a couple seconds before attempting to get a prompt from the uMP3; this lets the uMP3 player scan the connected media (note that if you format your SD card for FAT16 it takes a long time to scan — stick to FAT32). After the delay, we'll send CR until the prompt comes back. After that, we seed the random number generator value (*lottery*) and reset the song-played markers.

To keep everything manageable, I decided to limit the play list to 16 songs. What this lets us do is use a single Word variable to track the songs that have played in the current cycle. Since we'll want to reset the play list at the beginning of the program and when all songs are played, we'll put that function into a subroutine:

```
Reset_Markers:
  markers = $FFFF
  FOR idx = 1 TO NumSongs
    markers = markers << 1
  NEXT
  RETURN
```

■ FIGURE 4: uMP3 PLAYER



This is pretty simple, really, and yet a very handy trick. We start by setting all of the bits in markers to one, and then looping through the number of bits (starting at the LSB) that match our song count, clearing them to zero by shifting the other bits left. If, for example, we had on six songs in our play list, *markers* would be set to

%1111111111000000

by this routine. What if we want to extend the play list past 16 songs? That's not a big challenge, we just use two (or more) variables. Here's how we could reconfigure for 24 songs (one Word plus one Byte required to store the markers):

```
Reset_Markers:
  IF (NumSongs < 17) THEN
    markersHi = $FF
    markersLo = $FFFF
    FOR idx = 1 TO NumSongs
      markersLo = markersLo << 1
    NEXT
  ELSE
    markersHi = $FF
    markersLo = $0000
    FOR idx = 17 TO NumSongs
      markersHi = markersHi << 1
    NEXT
  ENDIF
  RETURN
```

Okay, now we get to the meat of things. The core of the program starts by tumbling the random number generator and then uses that value to select a song from the embedded play list. If the song has already played in this cycle, then we will go back to **Main** and try again. If the current song selection hasn't played yet, and it wasn't the last song in the previous cycle, we'll mark it, pass its number to **Play_MP3**, and on returning, check to see if all of the songs on our list have played. If that's the case, the list gets reset. Here's the core code:

```
Main:
  RANDOM lottery
  theSong = lottery // NumSongs
  IF (markers.LOWBIT(theSong) = 1) THEN Main
  IF (theSong = lastSong) THEN Main

Play_The_Song:
  markers.LOWBIT(theSong) = 1
  lastSong = theSong
  GOSUB Play_MP3
  IF (markers = $FFFF) THEN
    GOSUB Reset_Markers
  ENDIF
  PAUSE SongDelay
  GOTO Main
```

Okay, now for the hard work and, truthfully, it's not that hard. With the song number in hand, what we have to do now is tell the uMP3 to play it. Here's where we need to make a choice: We could choose to make the code very simple by forcing the file names into a non-friendly mode (e.g, "F001.MP3") or, we could work a bit with our program so that we can use the file names as-is. My choice is to spend a little effort writing code so that we don't have to do anything special with the file names on the uMP3 player module.

Let's say we had "Jingle Bells.MP3" in the root folder of our uMP3 and wanted to play it using a terminal program. We'd enter this command:

>PC F /Jingle Bells.MP3 [Enter]

If we keep all of our files in the root of the SD card, and know that all files have the ".MP3" extension, all we have to do is store the song title; we can do that like this:

```
MP3s     DATA     "Jingle Bells", 0
```

Using the z-string approach will allow us to scan through the memory to find the selected song, we just need to know where the list starts and what song number to play. Let's have a look at the code that sends the play command and song name to the uMP3.

```
Play_MP3:
  eePntr = MP3s
  IF (theSong > 0) THEN
    zCount = 0
    DO
      READ eePntr, char
      eePntr = eePntr + 1
      IF (char = 0) THEN
        zCount = zCount + 1
      ENDIF
    LOOP UNTIL (zCount = theSong)
  ENDIF

  SEROUT TX, Baud, ["PC F /"]
  DO
    READ eePntr, char
    eePntr = eePntr + 1
    IF (char = 0) THEN EXIT
    SEROUT TX, Baud, [char]
  LOOP
  SEROUT TX, Baud, [".MP3", CR]
  PAUSE 100
  DO
    SEROUT TX, Baud, ["PC Z", CR]
    SERIN  RX, Baud, [char, DEC pos, DEC loopNum]
  LOOP UNTIL (char = "S")
  RETURN
```

The routine starts by setting the variable eePntr to the beginning of the songs list (in **DATA** statements). If the song number is greater than zero, what we have to do is fast-forward through the list to the selected song title. This is a pretty simple matter: we simply read characters from EEPROM and count the number of zeros encountered. Notice that the loop that reads the characters from the **DATA** statements always increments the pointer after the **READ** instruction. This positions the pointer properly when the final zero

is located.

Okay, now that our EEPROM pointer is set we can start the command by sending "PC F /" to the uMP3. We'll follow that with a loop that reads and sends the characters in the song title. Finally, we append ".MP3" and activate the uMP3 with a CR. Pretty simple, isn't it? And remember that if we use a member of the BS2p family, we could put the songs list in another program slot and use the STORE instruction to point to that slot — this would let us have a very long list of songs. Using this strategy is great for multilingual applications where each slot represents a different language — the program just needs to point to the slot that has the language of choice.

One of the features of the uMP3 that's useful for this application is its ability to report status while a song is playing. We can get status from the uMP3 by sending "PC Z." This will give us a status character ("P" for playing, "S" for stopped, "D" for paused), the current position (in seconds), and the loop counter for the file. Note that the position and loop counter are returned as text, so we use the DEC modifier to convert the values on-the-fly. This is another reason we left the uMP3 player at 9600 baud — using numeric conversion modifiers (DEC, BIN, HEX) in SERIN doesn't work well above 9600 baud (because of the inter-byte processing required by the modifier).

A DO-LOOP structure is used to send the "PC Z" command and then wait for the status character, position, and loop count. In other applications, we might use the position value for prop synchronization, but we'll ignore that in this program. Once the status character changes from "P" to "S," we can return to the main part of the program and play another song.

And that's about it — a fairly simple program that lets us play full-blown MP3 files with a cool little player module. For those that are into prop building (and the candles program in October proved there are a bunch of you), this opens up a lot of neat possibilities. The program we just worked with plays continuously, but we could easily add a trigger input, perhaps playing a random tune when someone rings the doorbell. That would certainly be more cheerful that the ubiquitous "*ding-dong*," wouldn't it?

MP3S MADE EASY

If you're new to audio projects and don't have any tools for creating MP3s, you're in luck as a great one is available at no charge: Audacity. This cool bit of freeware lets you edit audio and export to a variety of standard formats. Audacity does not have the ability to create MP3s built in, but it does support an MP3 encoder DLL (called LAME), and that's available on the Audacity site, as well. I've used Audacity and LAME to create MP3s for my uMP3 player, and even ring tones for my cell phone.

A particularly useful feature of Audacity is the ability to record from your system's audio mixer. I've used this feature to convert MIDI files (available by the truckload on the Internet) to MP3s that I can load into the uMP3. To do this, you set Audacity's record input to Mixer, and then load the MIDI file into your normal media player (Audacity can open MIDI files, but not play or convert them directly). Once the MIDI file is loaded into your media player, click the Record button in Audacity, and then Start on the media player. Audacity will capture the audio stream and record it as a new track. When the MIDI file is done playing, click on Stop in Audacity. It's a pretty simple matter to trim the leading and trailing blank space before exporting the audio as an MP3. I've used this same technique to pull songs from a CD and sound FX from a DVD.

Finally, let me remind you that just because you can "rip" audio from a CD or DVD that you purchased, that doesn't mean you can play the file publicly — to do so without getting clearance from the publisher is illegal, so please don't do it. If you do want to build a prop or display that uses commercial audio, contact the publisher and do the right thing (i.e., pay the license fee). The artists of the world — starving or otherwise (and including me, an actor) — will thank you for your support.

Well, that's it for this month — and this year. Please accept my very best wishes for you and yours this holiday season, and let's hope that we all have a very happy new year. Until 2006, Happy Stamping! ■

Continued from page 6

READER FEEDBACK

colleges and technical institutes. These programs provide much of the high level theory and math as in four year engineering degree programs — just in a more applied manner.

Topics include amplifier design, digital logic, microprocessor systems design and programming, robotics, laser systems, and even semiconductor manufacturing technology.

NV should cover more on TECHNICIAN careers in future issues.

Glen W Spielbauer
Dallas, TX

FORMAT FOLLY

I'll be upfront and blunt. I think the new layout and format that debuted with the Nov. 2005 issue stinks!

It appears to be an attempt to blur the distinction between articles and advertisements, something I find annoying and distasteful. I subscribe to a number of complimentary industry and trade publications that have also chosen this path in recent years. However, since it's someone else's dime, I grudgingly put up with it.

However, with *NV*, I'm a paying subscriber and I have both a choice and an opinion. *NV* has been my favorite publication for some time. I read it for the articles and I use the suppliers and advertisers. I typically read it cover-to-cover the day I receive it. This was not the case with the November issue. I was so frustrated with the new format, I stopped reading it and never finished.

If your advertisers and sponsors have pressured you into this new style, you may want to reconsider. If I don't read the magazine, I won't see any ads. I hope to be a continuing loyal reader, but I prefer the previous layout and format. I hope it will return!

Len Taddei, P.E.

GOING UP

It was with great interest that I read L. Paul Verhages' piece on the Space Elavator. This idea,known by various names over the decades such as "The Bean Pole," The Lift Port, The Space Elevator, and to wax a bit literary, The Fountain of Paradise, to paraphrase Arthur C. Clarke. As we learn more about materials, the project goes from fantastic speculation (Tsiolkovsky) through design speculations such as by Hans Moeevic ("Kevlar needs more spinach" is the line I remember), to the recent past where talk of graphite or boron fiber compositions were talked of.

And now we have a carbon varient strucure called Nano Tubes with people putting seed money into the background engineering research that may make this practical someday on Earth. It is interesting to note that in several stories and articles in the past, Mr. Verhages' comment on building a Lunar or Mars system has also been mentioned in Dr. Clarke's book, which is an interesting read.

Keep up the good material.

Earl Bennett

Continued on page 86

NEW PRODUCTS

- HARDWARE
- SOFTWARE
- GADGETS
- TOOLS

DESIGN KITS FOR ADVANCED POWER SUPPLY APPLICATIONS

ASIC Advantage, Inc., and IXYS Corporation have collaborated to bring to market new design kits for low and medium power supply requirements. These design kits, to be distributed by both IXYS and ASIC Advantage, feature ASIC Advantage's line of Power Smart IN-PLUG® controllers and IXYS' broad range of power discrete and mixed signal products.

Featured design kits include a highly flexible low EMI platform for isolated and non-isolated AC to DC switch mode power supplies, featuring line and load protections, very high efficiency, and very low standby power. The first targeted design kit will be the ASIC Advantage IPS-DK18 / IXYS PN EVPS001 targeted for offline applications below 10W. Future design kits will focus on different features targeted at different power levels.

The ASIC Advantage line of IN-PLUG Controllers features Flyback, Feedback, PFC, Push-Pull, and LED controllers. These design kits feature IXYS' new rugged PolarHV™ Power MOSFETs. These design kits also feature IXYS' line of low conduction loss Schottky Diodes and ultra-fast, soft switching HiPerFRED™ Diodes. Feedback requirements will feature the LIA120 and LIA130 Optically Isolated Error Amplifiers, available from Clare Corporation, which combines error amplifier and optical isolation functions common in power supply applications.

Future design kits featuring products from ASIC Advantage and IXYS will continue to draw upon the unique strengths and capabilities of IXYS and ASIC Advantage. "IXYS continues to expand its presence in the consumer and white goods markets through strategic market relationships and expansion of product offering. IXYS, in cooperation with ASIC Advantage, brings more options for system designers in these markets to design products that maximize energy and cost efficiency", said Don Humbert, Vice President of Marketing for IXYS Power.

"In offering PolarHV Power MOSFETs combined with IN-PLUG Flyback, Feedback, PFC, Push-Pull, and LED controllers, IXYS and ASIC Advantage offer the best alternative to single-chip solutions. It brings designers a more competitive technology and removes the limitations inherent to single-chip implementations." said Eric Garcia, Director of Marketing for ASIC Advantage.

For more information, contact:
ASIC Advantage
Web: www.asicadvantage.com
IXYS Corporation
Web: www.ixys.com

MULTIPLE RPM SENSOR SUPPORT

Eagle Tree Systems now offers support for multiple RPM sensors with their latest Flight and Car Recorder products.

The Flight and Car recorders and Seagull Dashboards now support up to two RPM sensors. Users can now see the RPM of two motors on a model plane or heli simultaneously, or measure wheel slip or dual speed transmissions on model cars.

With the Pro Flight Recorder or Pro Wireless Dashboard Flight System, up to 4 RPM sensors can be monitored simultaneously, for more serious multi-engine aircraft.

Each RPM channel is available in the recorded file, can be graphed with the built-in graphing software, displayed on Virtual Instrument Panel PC software, and shown live on a Wireless Dashboard (either on the LCD, or in Live Mode with the Virtual Instrument Panel).

All new recorders shipped from Eagle Tree have support for this new feature. See their latest instruction manual for important information regarding multiple RPMs.

Note: Previous Recorders and Seagull systems require an upgrade to use the multiple RPM feature. See their website or email the company for more information.

For more information, contact:
Eagle Tree Systems
4957 Lakemont Blvd. SE Suite C-4 PMB 235
Bellevue, WA 98006
Email: sales@eagletreesystems.com
Web: www.eagletreesystems.com

MICROCONTROLLERS PROVIDE A STRONG COMBINATION OF FUNCTIONALITY AND PACKAGING FOR COST-SENSITIVE APPS

Designers of consumer electronics and industrial control applications can now take advantage of eight-bit microcontroller solutions that feature an attractive combination of performance, low power, and price. Freescale Semiconductor is introducing the S08QG family of highly integrated, cost-effective eight-bit microcontrollers (MCUs).

To deliver increased on-chip integration, MC9S08QG8/QG4 MCUs add an enhanced eight-channel, 10-bit analog-to-digital converter (ADC) designed for better resolution, speed of conversion, and low-power. The onboard analog integration allows customers to easily interface to analog inputs with minimal external glue logic. The inclusion of a serial communications interface (SCI), a serial peripheral interface (SPI) module, and inter-integrated circuit (IIC) bus modules maximizes the customer's options for external components to interface with and enables increased design flexibility.

Flexible timer options allow for greater software flexibility with the eight-bit modulo timer module (MTIM), as well as motion control capabilities with the two-channel Timer/PWM module (TPM). The combination of these components on a single chip reduces the need for external system components and can help decrease the overall system costs.

"By offering tightly integrated eight-bit MCUs that combine flexibility and competitive price points, Freescale is giving designers wide latitude in choosing the right devices for their systems," said Eddie Sinnott, eight-bit MCU operations manager for Freescale. "The 9S08QG8/QG4 MCUs provide designers with the necessary functionality at a very competitive suggested resale price to enable even the most demanding and cost-sensitive application."

The 9S08QG8/QG4 also offers on-chip integration without compromising the low power consumption demands of many eight-bit applications by offering a series of clock source options. The internal clock source (ICS) module provides an accurate, low power internal clock generator, eliminating the need for and cost of an external crystal or oscillator. The 9S08QG8/QG4 MCUs are capable of supporting external clock source inputs from 32 kHz up to 20 MHz.

"Indesign places a great deal of strategic value in our partnership with Freescale," said Jerry Gotway, president of Indesign. "The 9S08QG8/QG4's high level of on-chip integration at this price point creates a great foundation for the design of new products. In addition to strong product innovation and aggressive pricing, Freescale provides us with the tools, reference designs, and support we need to go to market quickly with a sustainable competitive advantage."

Freescale provides an out-of-the-box development experience with cost-effective boards, production-worthy code via software libraries, and the award-winning CodeWarrior™ development environment to help customers bring products to market easily and quickly.

- The 9S08QG8/QG4 devices include a background debugging system and on-chip in-circuit emulation (ICE) with real-time bus capture, to eliminate the need for expensive emulation tools

- A virtual lab allows customers a hands-on experience prior to purchasing; visit www.embeddedlearningcenter.com

MC9S08QG8/QG4 Product Features

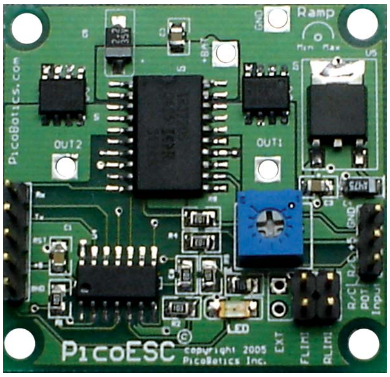
- Based on the HCS08 core
- Up to 20 MHz (10 MHz bus) at >2.1V operation for 100 ns minimum instruction time and 16 MHz (8 MHz bus) frequency at <2.1V
- 8K and 4K reprogrammable Flash options
- Synchronous and asynchronous serial peripherals (SPI, IIC, SCI)
- EIght-channel, 10-bit Analog to Digital Converter (ADC) with temperature sensor
- Analog comparator module (ACMP)
- Two-channel Timer/PWM module (TPM) and eight-bit modulo timer module (MTIM)
- Eight-pin keyboard interrupt (KBI) module with software selectable polarity on edge or edge/level modes
- Internal clock source (ICS) module containing a frequency-locked loop (FLL)
- External oscillator to support external clock sources
- System protection features, such as low voltage detect (LVD), power on reset (POR), and computer operating properly (COP) counter with independent oscillator
- Background debugging system and on-chip in-circuit emulation (ICE) with real-time bus capabilities

The eight-bit microcontrollers are available for the suggested resale price of $0.89 (USD) for the MC9S08QG4 and $0.99 for the MC9S08QG8 for 1K units MSRP on the least expensive package.

For more information, contact:
Freescale Semiconductor, Inc.
Web: www.freescale.com

ELECTRONIC SPEED CONTROLLER

The all new PicoESC™ from PicoBotics, Inc., is a dedicated serial slave DC brushed motor controller capable of operating from 6V to 24V @7 amps continuous (30A surge) and has a fully protected H-Bridge.



This tiny board can control a motor using either an R/C signal from an R/C source, from a potentiometer, or by sending commands using a 9600 bps TTL serial connection.

Users can adjust the soft start-stop via the on-board potentiometer to minimize stresses on geared motors. When an R/C signal is used to operate the motor, a fail-safe algorithm stops the motor if the signal is lost or becomes unreliable and will resume when the signal is normal again.

Other features include limit switch input, an on-board LDO regulator, and full-time serial control. This simple and inexpensive board is ideal for small to medium sized robots.

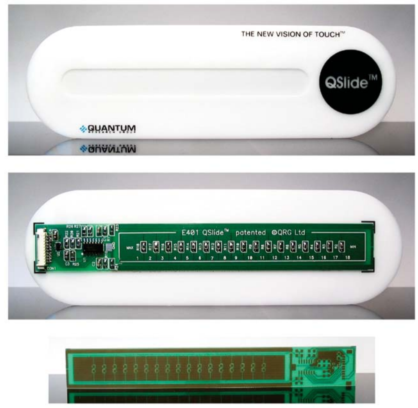
PicoESC has a very small footprint of 1.6" x 1.6" (40 mm x 40 mm), weighing only 0.44 oz (12.5 grams) and consumes only 2 mA (@12V).

The built-in TTL multi-drop asynchronous serial port allows up to 255 boards to be connected on a single serial bus.

The accompanying comprehensive user and technical manual explains all commands and functionalities in detail. PicoESC is priced at $34.95.

For more information, contact:
PicoBotics, Inc.
23 Rue Des Sources
Gatineau, QC
Canada J8V 1C7
Email: sales@picobotics.com
Web: www.picobotics.com

QUICKLY ADD ECONOMICAL SLIDER CONTROL TO YOUR PRODUCTS



QT401 is a 'slider' chip which uses Quantum Research (UK)'s patented charge-transfer sensing method to provide a reliable linear or arc-based touch-sensing output with a seven-bit resolution (1 in 128). This chip is ideal for control panels in appliance controls, personal electronics, automotive controls, or almost any consumer product where a knob or linear control (brightness, volume, temperature, power, etc.) is needed.

QT401's new technology uses a simple printed circuit resistive element as the capacitive sensor; and it will easily sense through 3 mm of plastic or glass. The output is an SPI serial signal. The sensor uses Quantum's proprietary charge-transfer ('QT') spread-spectrum sensing method to effectively suppress EMI noise problems; the result is a sensor that is extremely reliable and sealed. The data output can be interpreted as either a linear control or as a series of buttons, or a mixture of the two, depending on the needs of the designer. To create buttons from a slider, you only need to interpret number sub-ranges as being buttons. As many as eight buttons are possible in this way.

QT401 can even be used with clear Indium-Tin-Oxide ('ITO') sensing elements to create LED-backlit touch

zones with dramatic effect, or to indicate slider position after touch is released. This also allows the device to be used as an extremely inexpensive (yet near-indestructible) 'touch screen' strip over an LCD display panel, for much less cost than a resistive screen or mechanical 'bezel buttons.'

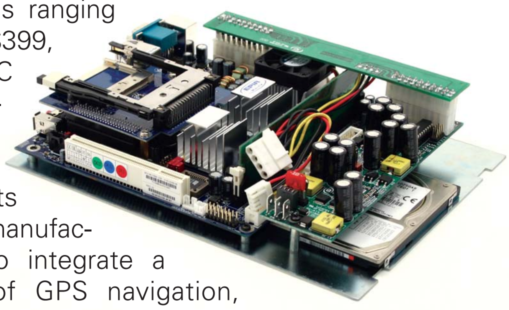
The E401 Evaluation Board lets you develop control panels with the QT401 QSlide chip. This board features an SPI interface; a USB adaptor comes with the E401 to allow the board to display its output on a PC. E401 shows how easy it is to add a low-cost touch slider into your product, and communicates with a PC to show the output of the touch slider in real time. This invaluable tool helps in optimizing the operation in your application.

The E401 Evaluation Board is available from stock at $95.00; QT401 is priced from $1.98 (5K).

For more information, contact:
Saelig Company, Inc.
Tel: 585-385-1750 Fax: 585-385-1768
Email: info@saelig.com
Web: www.saelig.com

FIRST SUB-$300
CAR PC KIT

VIA Technologies, Inc., a leading innovator of PC platform solutions, and Mini-box.com, a subsidiary of Ituner Networks Corp., announces the VoomPC™ family of compact, high performance, yet affordable x86 car PC kits aimed at driving telematics mainstream. Based on low power VIA EPIA Mini-ITX mainboards — the x86 platform of choice for car PCs — the VoomPC is specifically designed for the ultra power sensitive conditions of in-vehicle applications.

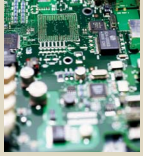


With prices ranging from $299 to $399, the VoomPC barebone platform is ideal for automotive enthusiasts and vehicle manufacturers alike to integrate a wide range of GPS navigation, communication, entertainment, and information functionality into private cars or vehicle-dependent professional service vehicles such as law enforcement, rescue, and commercial transport, where access to data on the road is essential.

All the critical power issues of car PC systems have been addressed. The VoomPC integrates the intelligent Mini-box M1-ATX 12V power supply unit to prevent system damage from power surges and eliminate car battery drain by monitoring car battery levels, even when the car is turned off. The energy efficient VIA C3 processor with its highly effective heat dissipation enables the VoomPC to consume between 15-30 watts, less than the dimmest car parking lights.

Compatible with all standard Linux or Microsoft® Windows® operating systems and built within Mini-box's signature compact chassis of just 21cm x 25cm x 6.7cm, the VoomPC is equipped with rich peripheral connectivity, multimedia, and telematics options afforded by the feature-packed VIA EPIA Mini-ITX mainboard, including USB2.0, Firewire, Ethernet, PCMCIA types I and II CardBus interface for GPRS/Wifi, S-Video, VGA, and six-channel audio.

For more information, contact:
VIA Technologies, Inc.
Web: www.via.com.tw
Mini-box.com
Web: www.mini-box.com



THIS MONTH'S PROJECTS

The Flying Marbellos 36
Electronic Rocket Launcher . . .46
Poor Man's CNC Machine 52

LEVEL RATING SYSTEM

To find out the level of difficulty for each of these projects, turn to our ratings for the answers.

●○○○ . . . . . Beginner Level
●●○○ . . . . . Intermediate Level
●●●○ . . . . . Advanced Level
●●●● . . . . . Professional Level

Click! ... Whirrr ... Hummm ... Bang!

These are the sounds of "The Flying Marbellos" — a rolling ball sculpture with marbles and small metal "bugs" to run the show.

LEVEL RATING: ●●◐○ (Intermediate)

THE FLYING MARBELLOS

The purpose of a rolling ball sculpture (RBS) is to transport balls to the top of a system of tracks, where they proceed to find different and amusing paths on the way down. Is this a silly thing to do? Yes! Do people love to watch these things for long periods of time? Yes! Put an RBS in a public place and you'll attract a crowd surrounding it. I love watching mechanical things, but building this turned out to be even more fun.

Since I have a fascination for mechanical things, and also enjoy working with BASIC Stamp microcontrollers, this 6-1/2 foot tall RBS finds some different ways of going up with the balls, as well as going down. It all starts with a motor that elevates the marbles to the top, and as they roll down, they encounter switches that change paths with every marble. The insects and spiders add a circus flair to the whole thing. A helicopter carries one marble from a low platform to a higher one so that it can begin another journey down. An elevator carries another marble to the top, sends it to drop through the air to a pad where it bounces up and into a basket. One marble lands into the muzzle of a cannon, where a bug lights a torch, leans over, and lights the cannon's fuse, and then the cannon fires the marble into the basket. Two marbles at once go down into a tube, where 90 LED

FIGURE 1. THE FLYING MARBELLOS.

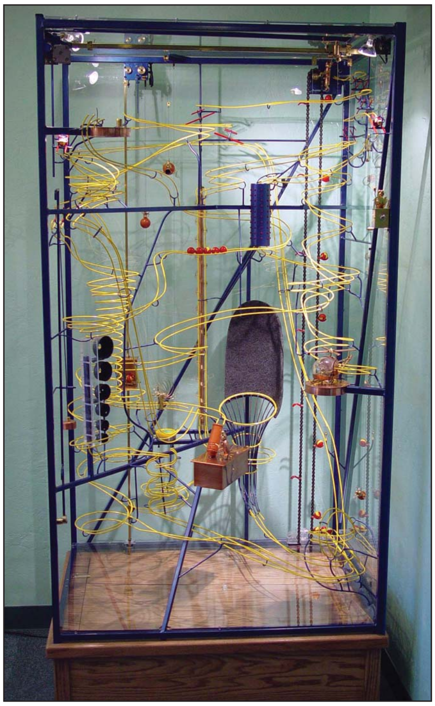
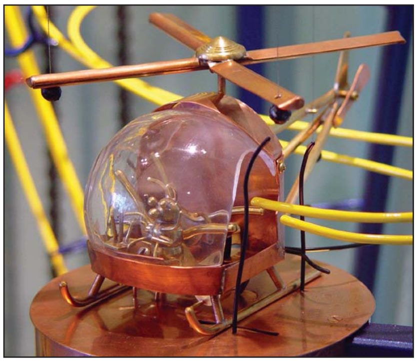
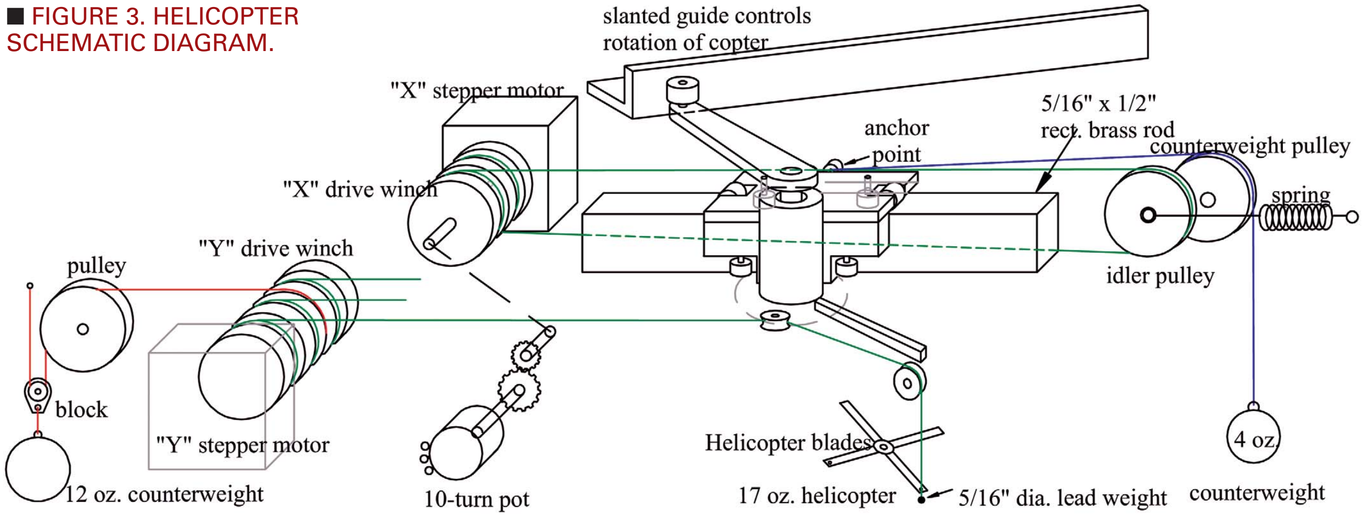


FIGURE 2. THE HELICOPTER.



■ FIGURE 3. HELICOPTER SCHEMATIC DIAGRAM.



lights follow the marbles, cascading in sequence down the tube. Others follow turns, loops, and spirals, jump from a ski jump, and ring bells on their way down.

Once in a while, a marble leaves the track and does not make it back on to the track. When this happens, a marble-rescuing machine takes the marble back up and puts it back on the track. Some RBSs are excellent at keeping all balls on the track for extended periods of time. When marbles bounce, jump, or get shot out of a cannon, this doesn't work as predictably. The marble rescuer keeps the machine going, despite losing its marbles now and then. It hasn't stopped me from losing my marbles, though. I noticed that if no marbles go onto the bottom for a while, observers start getting anxious to see it happen again, so that they can watch the rescuer put the ball back on the track. Maybe losing your marbles is not such a bad thing.

Gravity makes the marbles come down the tracks, and three BASIC Stamp microcontrollers help with the 21 switches, four stepper motors, one servo, and 92+ LEDs. I chose BASIC Stamps because they are so easy to use. Their online manuals and resources gave me plenty of information to learn to work with them, without my being an engineer. Coordinating the motors and moving parts required many changes of the program to get the right "look" and the right smoothness. With the Stamps, it was easy to make changes and evaluate their effects.

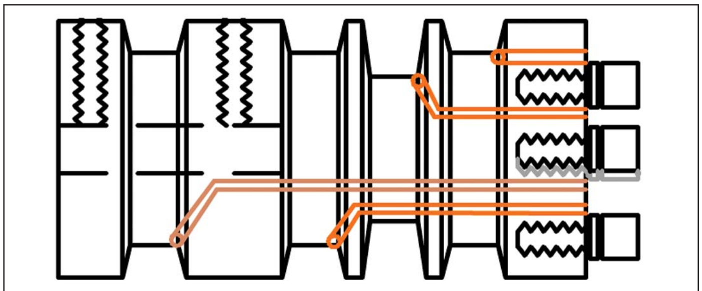
The Helicopter

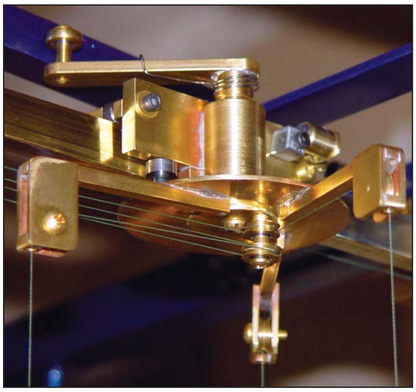
One of the big stars of the show (and certainly the biggest challenge) is the helicopter. When a ball rolls into the cockpit of the helicopter, it flies by means of fishing line leading to a trolley above. One stepper motor for the "X" (horizontal) direction of travel pulls the trolley on a track across the top of the machine. Another stepper motor raises the copter (the "Y," or vertical direction) so that when the two motors work together, they lead it on an arc to the upper platform. As the trolley travels from one side to the other, it also rotates the copter, so that at the top it is facing 90° from where it started. (See Figure 3.)

You might think that since you can control the speed of stepper motors, that you would have complete flexibility in controlling motion. There are some limitations. The motor's maximum speed of rotation is limited because they only work properly up to a maximum speed of the steps, and then the mechanics can't keep up with the electronics. With a "PAUSE 1" in between steps in the program, this comes close to the top speed of the motors I used, which have 200 steps per revolution. To get a fast enough maximum speed of motion, some mechanical advantage is needed. Using motors with fewer steps per rotation would also increase speed but sacrifice some smoothness in movement.

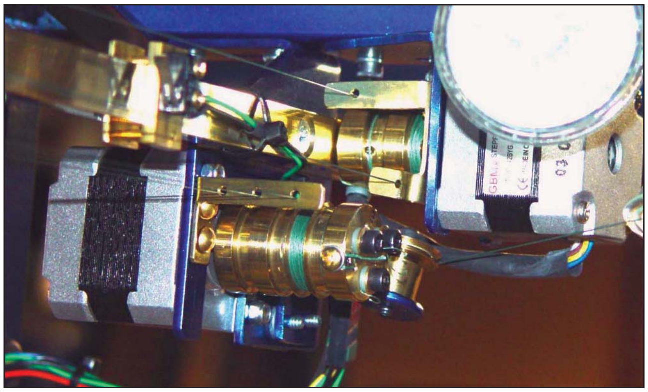
Each motor turns a drum that is a winch for the control lines (Figure 4). The diameter of each area that winds up a line affects the speed of motion. Most of my lines wind onto .770" diameter, which gives the speed that I want. When you use a larger diameter winch, this puts a heavier load on the motor. By using a counterweight, the motor just moves the load and does not have to lift it all. So then, at the same time that the winch is winding *up* control lines that raise the helicopter, part of the winch is *unwinding* a line going to a

■ FIGURE 4. THE WINCH REEL FOR COPTER "Y."





■ FIGURE 5. THE COPTER'S TROLLEY AT TOP.

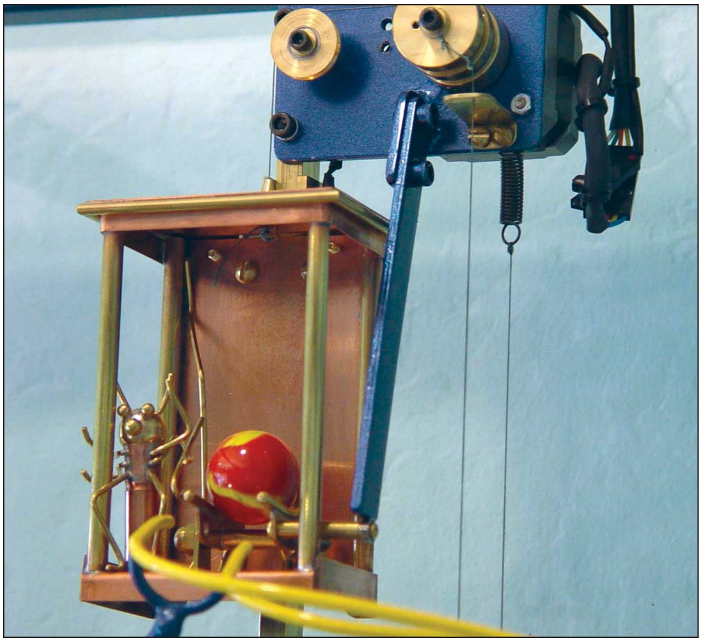


■ FIGURE 6. THE HELICOPTER'S DRIVE MOTORS. THE Y MOTOR IS ON THE LEFT, THE X MOTOR IS ON THE RIGHT.

counterweight. This counterweight lightens the load for the motor, and also balances the system so that when the power goes off, the copter remains in position instead of crashing. If the winch area for the counterweight is turned to a smaller diameter, then the weight will not travel as far. This will also require more weight, but means that the path of the traveling counterweight is shorter and can fit into a smaller area. I used a block with one counterweight to reduce the counterweight travel to half the distance.

The motor controlling the "X" direction turns a drum that pulls the trolley toward it. The line attaches to the trolley, continues to an idler pulley, and then returns to the drum where it unwinds on another part of the drum. The ball-bearing idler pulley keeps tension in the line with a spring. As the line winds in one spot and unwinds in another, the pulley moves about 1/4" as it keeps tension on the line. The line is 50 lb.-test multifilament "Spiderwire Stealth" fishing line (Wal-Mart). This multifilament line is thin, strong, Teflon lubricated, and it is limp — it has no "springiness" to make it misbehave. The action of the "Y" mechanism makes the trolley want to go to the left, so a counterweight pulls the trolley to the right to offset this.

■ FIGURE 7. THE ELEVATOR, ABOUT TO RELEASE A MARBLE. THE BLUE POST IN THE CENTER DUMPS THE MARBLE CRADLE.



The motor controlling the "Y" direction winds up three lines (16 lb — Spiderwire) on its drum winch to raise the helicopter, while unwinding another 50 lb. line going to a counterweight. The lifting lines attach to three points on the helicopter, and then lead up to a "Y" shaped yoke, where the lines turn around pulleys, lead to more turning pulleys in the center of the yoke, and then go to the winch. Since the yoke rotates as the helicopter travels, the turning pulleys in the center of the yoke keep the relative lengths of the lines from changing, which keeps the copter level while flying. The lines attach to the helicopter by going through a hole and attaching to a lead crimp-on fishing weight. When the copter lands, the weights can drop and keep tension on the lines so that they all stay on their pulleys. All of the pulleys use ball bearings.

The trolley is made of pieces of brass soldered together, with six bearings to ride the rail — two on top and two each on front and back (Figure 5). I tried making this trolley with a brass sleeve to ride the rail (as I did the elevator and rescue device), but there was too much friction. The helicopter rotation arm puts the center of weight off center from the rail, and the ball bearings are needed to make it travel smoothly enough.

The "X" motor also connects to a potentiometer, so that I can measure the position of the trolley with a Stamp. This is only for cases where power is lost, so that when power is restored, the copter can find its way back home. Otherwise, it is almost sure to crash when the power goes on. One way the power can go off is when someone thinks that the way to turn off electrical things is to unplug them (been there, done that). To ensure that this can't happen during normal operation (turning it off with the switch), a relay holds the power on to the Stamps and motors until the copter lands. The spot lights and ball-lift motor turn off, but the helicopter finishes its journey before all shuts off. This feature was disabled during most of the development of this project, when I wanted the copter to stop if I switched it off.

The pot is a 10-turn wire-wound pot that is connected by gears to the "X" motor. The gears make it so that the pot turns no more than its maximum 10 turns during the trolley's travel. The "Y" Stamp can know where the trolley is with an RC circuit, and do the right thing with getting the copter home in the vertical direction. This is especially important near the top of the arc-shaped flight path, where

"Y" may have to go up before it starts going down. I calibrated it by guessing some numbers for RC time, and having an LED flash different numbers of times for different positions. I then moved the trolley by hand and marked the positions where the number of flashes changed. It only took a few tries to get a scale of numbers corresponding to the trolley position. Limit switches tell me if the copter is at the ends of travel in the "X" direction, and if it is landed at its home landing pad. I did not use a limit switch at the upper landing, and instead used the precision of the stepper motors counting steps to determine the final position at the top landing. This works just fine, but if I had it to do again, I would have a switch there, too, as it would make programming the flight path much easier. Another switch detects if a ball has loaded into the helicopter. Leverage is needed to convert the tiny movement of a microswitch into a larger movement that a marble can easily trigger.

The flight path of the helicopter can be calculated and worked out before ever flying it, but it turns out that doesn't help much. One needs to see it working to evaluate the speed and smoothness of the movements. You can get an idea by turning the winches by hand and counting the turns. Make an educated guess, and watch it fly. It becomes immediately obvious how to tweak the numbers to get on the right path. Getting it close is not too tough. Getting it just right is an art. The easy reprogrammability of the BASIC Stamp comes to the rescue.

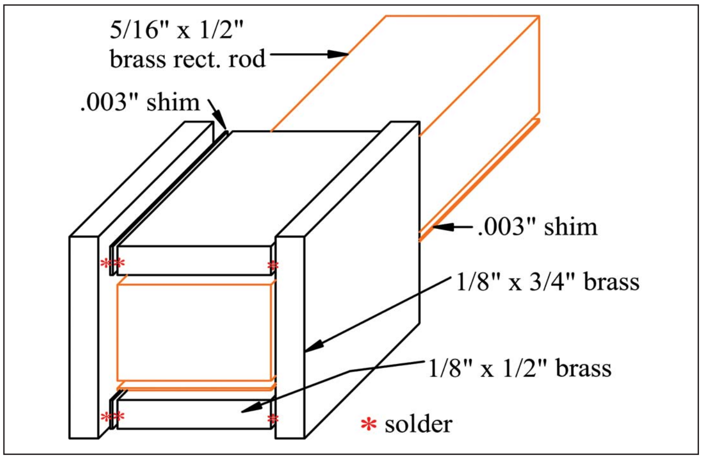
The Stamp controlling the "Y" direction also controls the rescue device. When it is involved in a rescue, it signals the "X" Stamp that it is busy, so that both Stamps will be able to start together when flying the copter. The "X" Stamp tells the "Y" Stamp to start, but will not tell it until the "Y" Stamp no longer gives a busy signal. If one motor is trying to fly the copter while the other one is unavailable, all kinds of bad flying can happen.

I also made a hidden test button, which could be used to start partial flights. A quick push gives one flight path, and a longer push gives a different path. This was really useful when programming the flight path. In the final version, I use it to fly the copter only one way: to land on the top and stay there, which is useful for transporting the RBS.

When the helicopter lands at its temporary upper landing or at its home landing pad, there is some sway to it. Since it is important that it land predictably in the right place, there are guide rails to assist it. At the base of the copter is a "V" shaped guide rail on each side, and the bottom skids of the copter also assist in guiding. On the landing pads are vertical rails that guide it into position, one at the top pad and three at the bottom. They are made of 1/16" brass rod, and painted black to make them inconspicuous.

The Elevator

The elevator has a similar operation to the helicopter. A stepper motor winches the elevator up, while at the same time lowering a counterweight down (Figure 7). A guide pulley separates the elevator and counterweight far enough from each other so that they don't hit each other during travel. Limit switches at the top and bottom tell the Stamp where the elevator is, and an "elevator loaded" switch tells when there is a marble in the elevator waiting to go up.

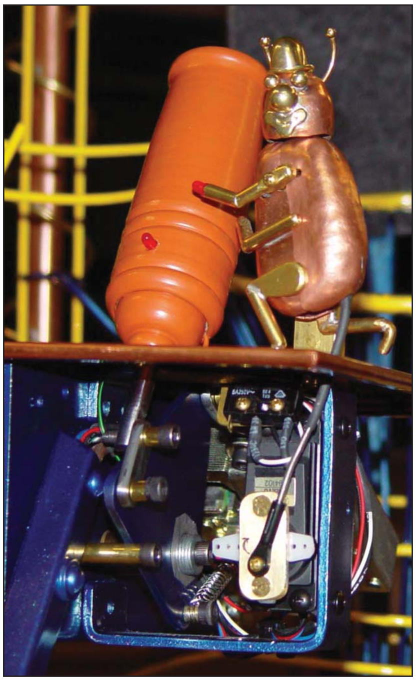


■ FIGURE 8. SLIDE FOR THE ELEVATOR OR THE RESCUE DEVICE. THE BRASS RECTANGULAR ROD AND THE SHIM WITH IT ARE REMOVED RIGHT BEFORE SOLDERING.

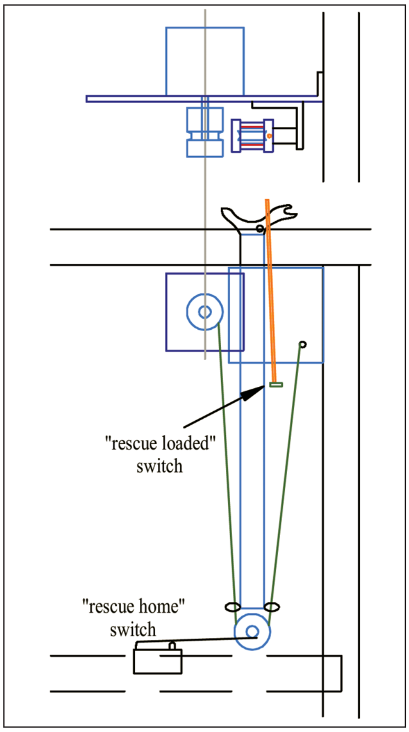
The elevator is attached to a slide that rides on the same kind of rail (rectangular brass rod) as the helicopter. The slide is soldered together out of pieces of brass (Figure 8). On one side some pieces of .003" brass shim are soldered in to give clearance. The whole thing is clamped together with it around the rail and another piece of shim. Then the rail and one shim are slid out, and

RESOURCES

- McMaster-Carr — *Great source for brass, steel balls, tools, gears, chain, bearings.*
  www.mcmaster.com
- Jameco Electronics — *Electronic parts, steppers*
  www.jameco.com
- Parallax, Inc. — *BASIC Stamps and tons of free information on how to use them.*
  www.parallaxinc.com
- ServoCity — *Servo motors, linkages*
  www.servocity.com
- Sherline lathes
  www.tabletopmachineshop.com
- Little Works of Art Marbles — *Incredible selection of marbles*
  www.emarbles.com
- Rolling Ball Sculpture Forum — *A discussion group where you can get help and search for information.*
  http://groups.yahoo.com/group/rollingball sculptures/
- Small Parts, Inc. — *Where you find heat shielding compound, and other useful things.*
  www.smallparts.com
- Micro-Mark — *Telescoping brass tubing, Universal Bender.*
  www.micromark.com



■ FIGURE 9. THE CANNON-LIGHTING CLOWN BUG, AND THE SERVO UNDERNEATH THAT MOVES HIM.



■ FIGURE 10. THE RESCUE DEVICE.

it is soldered. It is important that the solder is flowed in from the outside, and in sparing quantities so that it doesn't get inside of the slide. This gives a slide that is .003" bigger than the rail. When the motor lifts from the center of gravity of the elevator, and two coats of car paste wax are on the rail, it slides up and down easily.

The Rescue Device

The rescue device uses the same type of rail and slide, only this time the slide holds still, and the rail moves (Figure 10). A slower speed allows a smaller winch diameter, and the stepper motor is strong enough to operate it all without a counterweight. Limit switches detect when the device is at the bottom, and when it is loaded with a marble. I didn't feel a switch was needed at the top of travel since the number of steps that the motor makes can govern this quite well. It just needs to start from the lowered position. It is then possible to finely tune the height when it is raised by changing the program on the Stamp.

The Cannon

The cannon is shot by a 120 VAC solenoid, where a cam arrangement transfers the travel of the solenoid into pushing a rod into the bottom of the cannon (Figure 11). I tried 12 VDC and 24 VDC solenoids to do this, but none of them were strong enough at the currents that I used to do the job. The AC solenoid gives 7 lbs. pull when it shoots the marble 6-15" high, and more would be better. It is triggered by a Triac driver (optical coupler) and a Triac. I thought that the Triac would give a predictable velocity to the shot since it always switches at the same place in the changing AC voltage, but this was not the case. I think the shooting power is variable because of less-than-perfect sphericity of the marbles, and less-than-perfect walls of the PVC pipe that I made the cannon barrel from. If one in 10 shots miss the basket, then we get to watch the ball rescue device in operation.

The cannon is "lit" by a circus clown bug. He holds an LED "match" in his hand. The match lights, and he leans over to light the LED "fuse." As he leans over, he extends his match arm to light the fuse, kicks a back leg into the air, and turns his head 90° toward the cannon. A servomotor moves it all. The bug's body movements are managed by the front of the bug rotating on a different axis than the back half of the bug. When he leans over, the relative motions of the two halves can make the arm, leg, and head move. This part of the project made me feel like a watchmaker. Do you think Mr. Rolex ever played with servos, LEDs, and bugs? Maybe not, but then he probably had all of *his* marbles.

Servos need to be on a separate power supply than the BASIC Stamps. The servos draw a bit of power, and cause the voltage to drop enough to "brown out" the supply, which would cause a Stamp on the same supply to reset.

The LED Cascade

Ten circular rows of nine (5 mm) LEDs surround a tube through which two marbles travel. The lights follow the path of the marbles as the go down the inside of the tube. Actually, the first marble hits a microswitch before it gets to the tube, and the lights follow a predetermined sequence that *appears* to follow the balls. The mechanical marble switch that precedes this lets go of two marbles at once (Figure 13). A marble separating mechanism is needed so that the two marbles are not right next to each other, to get the effect that I wanted. A tight spiral inside the tube makes the marbles go down the tube more slowly as they spin their way down.

More Electronics

The whole thing (Figure 12) was wired with point-to-point wiring on a perforated circuit board with pads at each hole. A printed circuit would be nice, but since I made a lot of changes, additions, and deletions during the development, I think point-to-point was actually easier. Connectors were essential to be able to plug and unplug the board from everything else. Resistor networks would have been nice, if I had only realized from the beginning how many resistors of the same values would be used.

I used three BASIC Stamps — each one to control several functions. This saved cost, but added complexity to have the microcontrollers alternating tasks. Using more Stamps would have raised the cost, but would also have saved a lot of time in getting all of the activities to coordinate with each other, and would simplify the programming. I used a BS2SX, a BS2p24, and a BS2p40. It all could have been done with four or more BS2s, but I used some Stamps that I already had on hand.

My power supplies were wall warts and table top supplies. The Stamps need an electrolytic capacitor across the output of their supply, to help avoid brown-outs and resetting. The spot lights are 12 VAC halogen reflector lights (a 35W and two 20W), using a power supply made for these.

Marbles, Tracks, and Construction

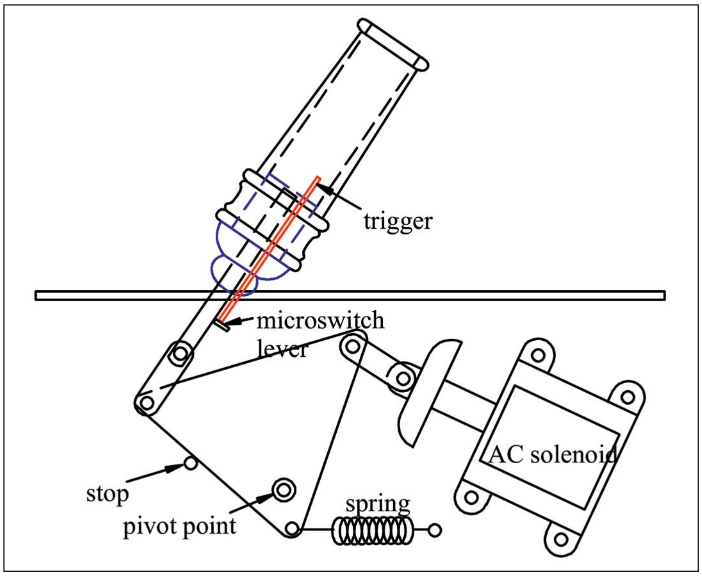
The tracks are all made of 1/8" diameter steel welding rod, brazed together. Semi-circular crosspieces keep the track spacing and give places for supports to attach. When one piece of rod is used, the next one is butted to it and brazed end-to-end. I made a bunch of jigs that hold the cross pieces in position for brazing to the track. They clamp on with 8-32 Allen cap screws. Tighten the screws with a 9/64" Allen ball driver, with a screwdriver-type handle. This tool will reach into and around a lot of tight places, and tighten the screws even when it is 25° out-of-line with the screw. RBS construction creates lots of tight places. Track can be bent by hand, pliers, and a vise. A wonderful bending jig can be purchased at Micro-Mark (**www.micromark.com**) Flower pots make good round forms in varying diameters for bending the rod. A great idea I learned a little too late for this RBS — fill a big traffic cone with cement. When it hardens, you have a heavy, stable place to bend many different diameter curves. All methods are useful, as each situation may require a different bending technique.

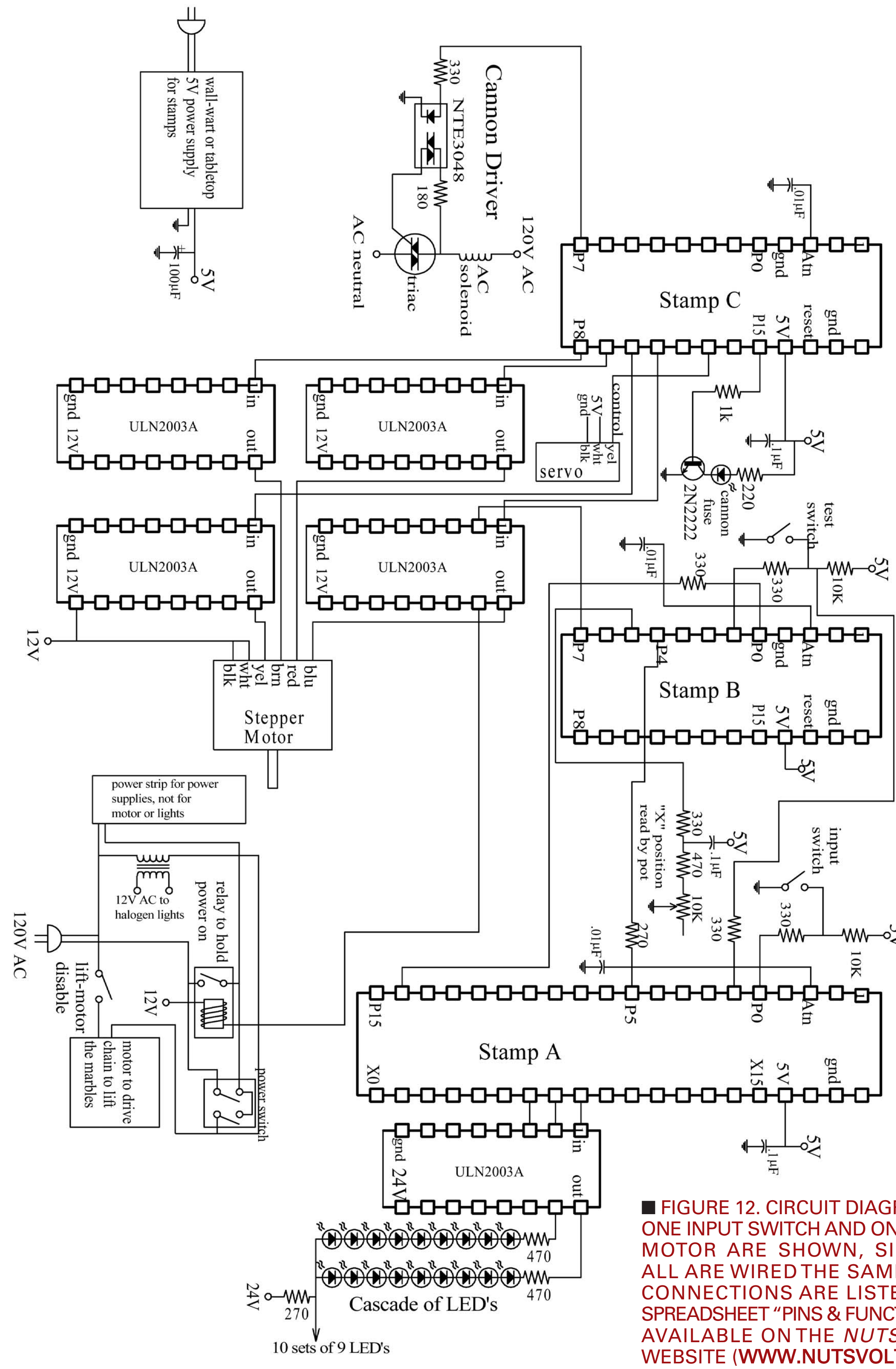
The tracks need to be banked so that a marble going around a curve does not fall (or fly) off. This is directly affected by the weight of the marble and the speed it is going when it hits the curve. The weight should be controlled by marble selection. The consistency of weight is more critical if the marbles bounce, leap, or get shot from a cannon. Buy 100 marbles, weigh them, and sort them into piles. See what weight range has the most marbles, and with luck there will be 20 marbles that are within 0.2 grams of each other. Use these "official" marbles to operate the RBS. Now save a slightly heavier and a slightly lighter marble for testing. An official marble may negotiate a curve almost every time, but the lighter and heavier ones find the curves that are banked *almost* right, and help you figure out whether they need more or less bank. Test each foot or two of track as you make it, as it is a lot easier to change the angle of bank before too much track comes after it. The track spacing affects the speed: wider makes the marble roll slower, and makes banking less critical. Narrower spacing makes the marble roll faster, but the angle of bank on the curves is more critical, and it is easier for the marble to leave the track. I used 15/16" diameter marbles (they are listed as 1"), and the inside distance between tracks is 3/4". It is a good idea to have selected the marbles before making the tracks.

Brazing is very easy to do, using an oxy-acetylene torch and brass brazing rod. It is similar to soldering, but is very strong and not as watery when melted. It is easy to make joints that are smooth and nice-looking. Use plenty of flux, made into a paste and applied with a little brush. I use Harris Stay-Silv White Brazing Flux. After the joint is made, the flux will be very difficult to remove. Just scrape off the part that the marble touches, and leave the rest there. After a week or two, this flux will have picked up moisture from the air and softened, and a wire brush in an electric drill will remove it fairly easily. The wire brush will seem to barely affect it if it is used too soon after the joint is made. Many times only a few places need to be brazed, so that those joints can hold things in place while the next joints are made. A handy *timesaver* is a "gas saver." It gives you a hook to hang your torch, where the weight of the torch causes some valves to turn off the torch. A tiny pilot light stays lit. When you need the torch, you pick it up, pass it across the pilot flame, and go. The settings that control the flame are just the way you left them, and you save a lot of time in turning on valves, lighting the torch, and adjusting the flame.

The main frame around the whole thing is made from welded 3/4"square steel tube, with 1/2" square struts. Welding is not as easy as brazing, but with a grinder and some Bondo and some paint, even my amateur welds look fine. After everything is made, remove the flux, and lightly sand it. A sandblaster would be perfect if you have access to one. Then spray paint the whole thing with a darker background color, and then brush paint just the tracks with a lighter, brighter color. The paint on the tracks holds up pretty well. It will wear off of some very small and narrow areas, but the overall "look" is still there. After it is paint-

■ FIGURE 11. THE CANNON MECHANISM.





■ FIGURE 12. CIRCUIT DIAGRAM. ONLY ONE INPUT SWITCH AND ONE STEPPER MOTOR ARE SHOWN, SINCE THEY ALL ARE WIRED THE SAME. ALL PIN CONNECTIONS ARE LISTED ON THE SPREADSHEET "PINS & FUNCTIONS.PDF" AVAILABLE ON THE *NUTS & VOLTS* WEBSITE (**WWW.NUTSVOLTS.COM**).

ed, the tracks are waxed with automotive paste wax.

The marbles are lifted to the top with hooks brazed onto number 41 chain. To braze the hooks onto the chain, the chain is first cleaned in the spots to be brazed with white gas to remove the grease from the chain. The white gas is then removed with acetone. The spots for brazing are then ground to expose fresh metal with an abrasive disk or wheel, and now they are ready for flux and brazing. A motor turns sprockets at 10 RPM, to power the chain to the top.

RBSs are a magnet to children, and if they can touch, they will. I covered the whole thing with acrylic — 3/16" thick on the sides, back, and top, and 1/4" on the more frequently removed front. The floor is the wood top of the cabinet underneath. Over this is a slightly slanted floor of 3/16" polycarbonate (unbreakable plastic). This is shaped to lead wayward marbles into the marble rescue device. It is odd that many people do not even notice the slanted plastic floor, and think that there must be hidden magnets that lead the marbles into the rescue spot.

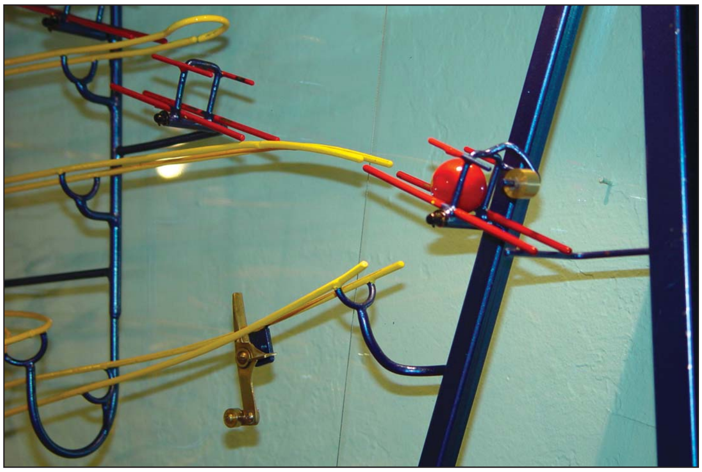
Bouncing a Marble

One popular feature is where a marble leaves the track and drops 25 inches to a pad, bounces 21 inches high, and then lands in the basket. This is like the rescue device — people watching the whole display can't wait to see it bounce again, though half the time they get distracted by something else and miss it. Too many things happening at once is a good thing. It makes a person want to stick around and keep watching.

The bounce pad is made from a slice out of the center of a Superball. The ball is made of some of the bounciest stuff invented by man, and they call it Zectron. Dr. Seuss couldn't have picked a better name. I embedded the ball in plaster inside a small wooden box. Brass nails stick out of the ball in areas that will avoid the path of the saw. The plaster grips the nails, which hold on to the ball as it is cut. The box, plaster, and ball are all cut together into slices with a table saw. When the pieces are disassembled, a nice 7/16" thick pad of Zectron is what remains. The pad is mounted on a 1/2" thick disk of steel plate. Thinner steel does not work so well, as the heavy mass of the steel is needed under the Superball for a good bounce. The steel disk rests on machine screws that fit loosely into holes in the underside of the disk. These screws can be adjusted to "aim" the plate and direct the bounced ball into the basket. Another machine screw is threaded into the bottom of the disk to hold it down. A plastic rim circling the pad is screwed to the steel disk and holds the pad in place, assisted by epoxy glue.

Metalworking

One of the useful tools for the mechanical parts is a lathe. I used a small and relatively inexpensive Sherline lathe, which did the job well. One thing the lathe can do is drill a hole into the center of a turning piece. If the work turns and the drill holds still, the drill automatically wants to go into the center. The lathe can accurately enlarge holes in gears or sprockets to accommodate a shaft. Bushings can be made to make a large hole fit on a small shaft. Freehand turning of insect parts, pulleys, or the important plumb bob is enjoyable.



■ FIGURE 13. MARBLE SWITCHES. THE ONE ON THE RIGHT WAITS FOR TWO MARBLES, WHICH GO THROUGH THE MARBLE SEPARATOR TO THE LEFT.

Almost everywhere there is a rotating part, I used ball bearings. A pulley is made so that the inside diameter of the pulley is .001" smaller than the outside diameter of the bearing. The two are pressed together, and they stay together. A lathe will also cut brass tubing precisely, so that spacers and bushings can be made. Several sizes of telescoping brass tubing came in handy for making everything fit together. A center drill is perfect for starting holes. It is a tiny, short drill on the end of a much thicker shaft. This keeps the point from bending to the side, and allows for accurate hole positioning. With a center drill, a drill press, and decent eyesight it is possible to get holes within .006" of where you want them.

The bugs were made of copper and brass. Sheet copper can be worked by annealing — heating it red hot and then quenching it in water. It is worked by pounding it with a rubber mallet over a metal or wood form, or a metal hammer against a plastic or rubber form. As the copper is worked, it gets work hardened. Anneal it again, and then work it some more. It sometimes takes 8-10 times of annealing and working it to get to the shape you want. Brass is annealed by heating it red hot, and then allowing it to cool slowly on the bench. When the shaping is done, the piece can be pickled for five minutes in a 10% solution of sulfuric acid to remove the oxidation. Fine steel wool gives a nice appearance after that. Pumice on a wet rag wheel gives another nice finish, and Tripoli metal polish on a dry rag wheel will make it very shiny. Gold rouge will make it into a mirror finish.

The pieces are soldered using 96/4 tin/silver "silver bearing solder." It comes from the hardware store in thick wire form. I pound it flat with a clean hammer

against clean steel, and then cut it in half lengthwise with tin snips. Cut it and split it again until there are pieces 1/4, 1/8, and 1/16 the size of the original wire. The pieces to be soldered are cleaned with fine steel wool and painted liberally with "LA-CO Regular Soldering Flux Paste" — the stuff plumbers use. After the pieces are clamped or held into place, the solder is cut into tiny pieces and set right next to the joint to be soldered.

The trick is to heat the pieces to be soldered with a propane torch, without allowing the torch to directly heat the solder or the flux. The flux burns at only a slightly higher temperature than the solder melts. If the piece is heated too long or too hot, or the flame spends too much time on the flux, then the flux will burn. Heat the work slowly, moving the flame so that everything heats evenly. Sometimes you touch just the very edge of the side of the flame to the work. When everything is hot enough, the solder melts and flows right into the joint. If the flux burns and turns brown or black, the solder will never flow. The only solution is to take it all apart, clean it again, and start over. If the flame is too big to heat the pieces without getting the flame on the joint, then a smaller flame is needed. There are some refillable butane torches that have a very tiny flame.

Heat shielding compound is reusable clay that can hold a soldered part in place while you solder another part right next to it. It can also be used to hold parts in position for soldering. As it heats up, it gets hard, and also keeps too much heat from getting to the parts that it protects. When done, spray it with some distilled water and put it in a jar, and it can later be used over and over.

Why RBS?

This was a truly fun project to build. Getting each stage working was a challenge, and was satisfying to see it work the way I wanted it to. In a public place, people love to watch these kinetic art machines, and sometimes there are crowds that can accumulate. I heard complaints that sometimes a person could not get close enough to see what was happening. "The Flying Marbellos" won "Overall Best of Show" at the Solano, CA County Fair, and I hope to display it at the California State Fair next summer. It is currently on display in my office waiting room, along with my musical water fountain "H-2-Opus" (*Nuts & Volts*, June 2003). ■

NOTE: Code listings for this article are available at the Nuts & Volts website (www.nutsvolts.com).

About the Author

■ *Victor Chaney is a dentist in Vallejo, CA. His website at www.chaneyproductions.com has videos, more pictures, drawings, and Stamp code. He can be contacted at chaneyv4@sbcglobal.net*

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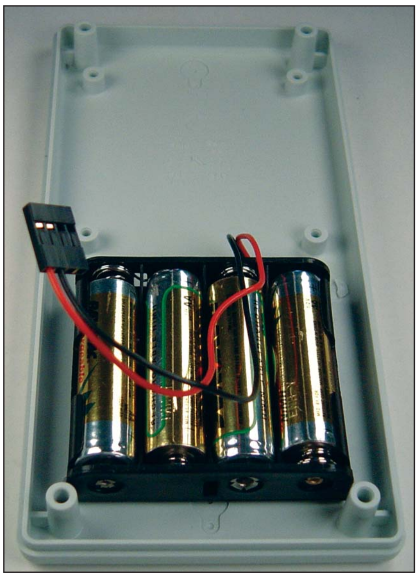
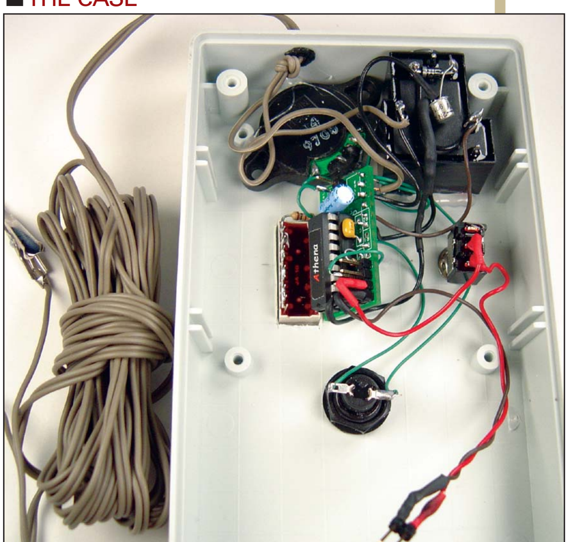
In this article, I will show you how to build an electronic launch control with the Athena microcontroller.

■ THE BATTERIES



■ THE CASE



■ LEVEL RATING: ●●○○ (Intermediate)

ELECTRONIC ROCKET LAUNCH CONTROL

My son and I have been avid model rocket enthusiasts for years. We have used various launch pads and controls over the years. One thing we have noticed is that they are being made cheaper and cheaper. Several times we have gone to use the control, and it just would not work. They are not that expensive, and for around $7, you can pick one up. What it comes down to is you get what you pay for.

I decided to build one that was durable, reliable, and safe. I wanted to keep the cost down, so I chose the Athena microcontroller as the brain. Let me go over how the unit works.

The master switch is the arming and reset switch. When turned on, the unit does a pre-check and indicates with LEDs the status of the igniter clips. If they have a good connection, all LEDs will light. If not, only the two outside LEDs will light indicating the unit is armed but has a bad connection.

The launcher will not allow you to proceed with a count down until the proper connection has been made.

During field tests, we found that on sunny, days it was difficult to see the LEDs, so we added sound. When armed, the unit now has a high frequency tick if a good connection to the igniter is made, and a low frequency tick if not.

Once you have a good connection to the igniter, you can push the start countdown button. As a safety feature, you must hold down the button for the complete count down. Each LED will blink out and a beep will be heard. This beep will go up in frequency slightly with each count. If igniter connection is lost or you lift your finger from the start launch button, the unit will abort the count down. Once aborted, you are required to reset the launcher by switching off, then back to arm position.

Once the countdown has completed 10 steps, the launcher will beep several times and the main relay will close causing full battery power to be applied to the igniter. Depending on how fresh your batteries are, the igniter will light in a second or two and the rocket will launch.

Hookup

In order to make assembly as simple as possible, I will break the project down into four schematics. To make assembly even easier, you can use an Athena Carrier 1u.

LED Section

Whether you are using a 10-segment bar or individual LEDs,

the anode of each LED is connected to ports 0-9. All the cathodes are connected together, then to VSS through a 100 ohm resistor as shown in Schematic 1.

Connections are the same when using the Athena Carrier 1u. You should assemble the carrier as indicated by the included instructions but leave off the headers so you can connect the LEDs directly to the board.

Power Section

If you decide to use the Athena Carrier 1u, then C1, C2, and R1 will be included on the board. These components are only needed if you plan on building your own circuit as shown in Schematic 2.

When using the 1u Carrier, I used a two-pin header on the + and – pins located next to port 8. You then have two choices on connecting the power/switch to the PCB. You can solder directly to this header or you can create a plug using a female header.

Launch Switch and Sound Section

Here we tie the launch switch to port 12 and VSS and the 130 ohm speaker to Port 14 and VSS as shown in Schematic 3. Again, the connections are the same for the 1u Carrier.

Igniter Section

The NPN transistor is a generic 2N2222 and I soldered mine directly to the relay. Just about any 10-20 amp relay can be used as long as its rated at 5V.

The igniter clip connected to VSS should be connected as close to the battery as possible. Also, the K1 coil lead connected to VDD should be connected as close as possible to S1.

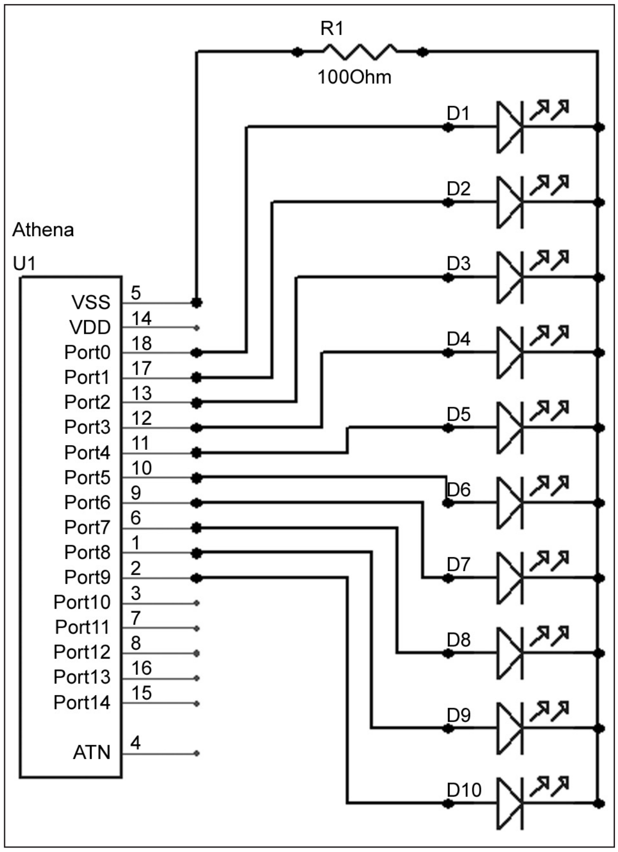
Layout

You can leave off the LEDs if you wish, or use an LED bar like I did with my launcher. All Electronics sells them (www.allelectronics.com). An LED bar is nothing more than 10 LEDs mounted in a plastic housing. I used the Athena Carrier 1u mounted directly to the LED bar. Everything on my launcher was held in place with hot glue.

You can use any case that will allow all the parts to fit. If you don't cramp the parts too much, it will be easy to add firmware changes to the Athena chip.

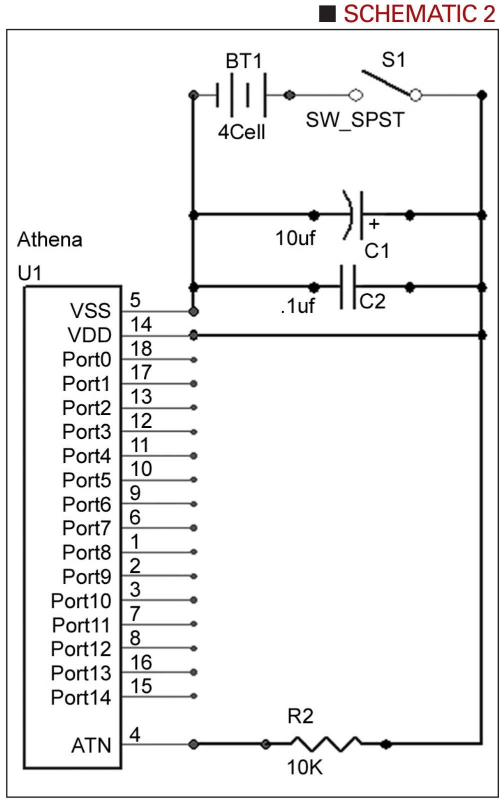
I used the igniter cable from an old launcher, but it is very easy to build your own. On my next launcher I will probably use 18 gauge wires with 26 gauge on the last 10". This will allow me to transfer more power to the igniter, yet keep it flexible enough not to pull out the igniter.

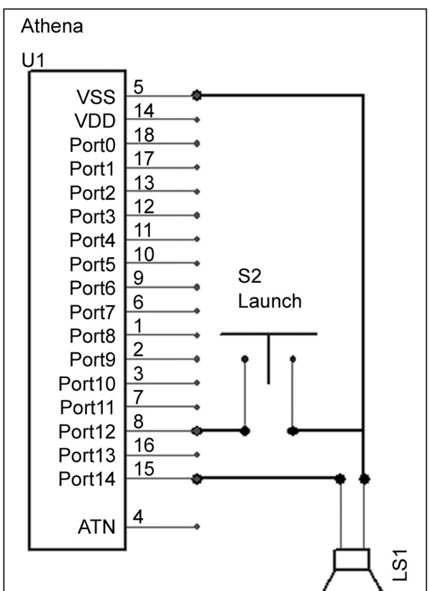
I use four rechargeable batteries for my launcher. Rechargeable batteries deliver more amps to the igniter than



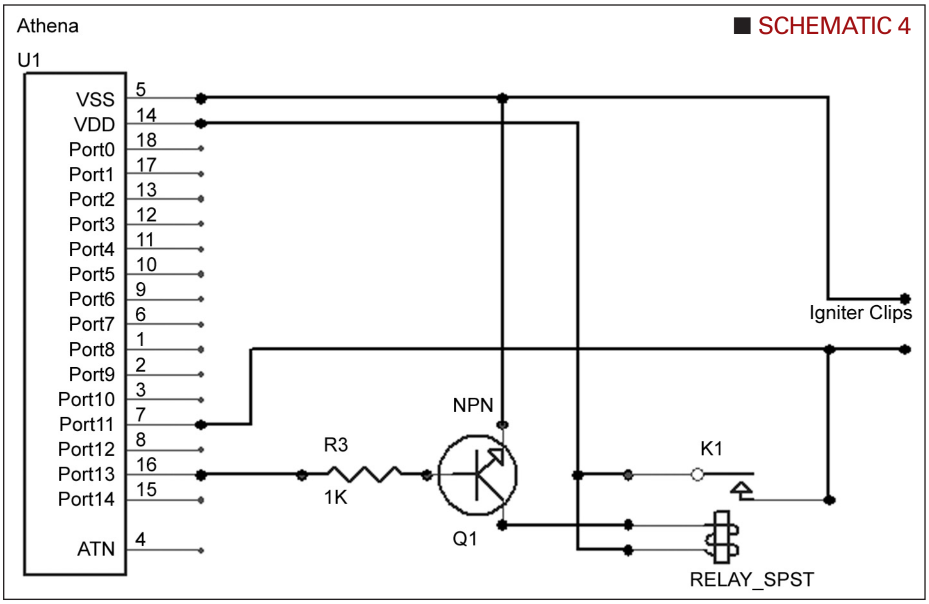
■ SCHEMATIC 1

■ SCHEMATIC 2





■ SCHEMATIC 3



alkaline, but both will work. The battery holder is mounted on the back panel of my launcher but you can mount yours anywhere that is convenient.

When assembled, place some foam rubber over the batteries to keep them from popping out if the launcher is dropped.

The Program

The program shown in Listing 1 (go to the *Nuts & Volts* website for Listing 1; **www.nutsvolts.com**) is broken down into four sections:

Setup

Here we set up the I/O ports and internal pullup resistors. We clear all variables and check to make sure the launch button is not pressed on startup.

Arming

Here we check to see if the igniter wires are connected. If they are, we allow the launce button to be pushed.

Launch

Once the launch has started, we remove the lit LEDs and beep the speaker. We also continue to check the status of the launch button and igniter wires.

Error Handler

If we get an error or abort, these are the handler routines that let you know something is wrong.

Going Further

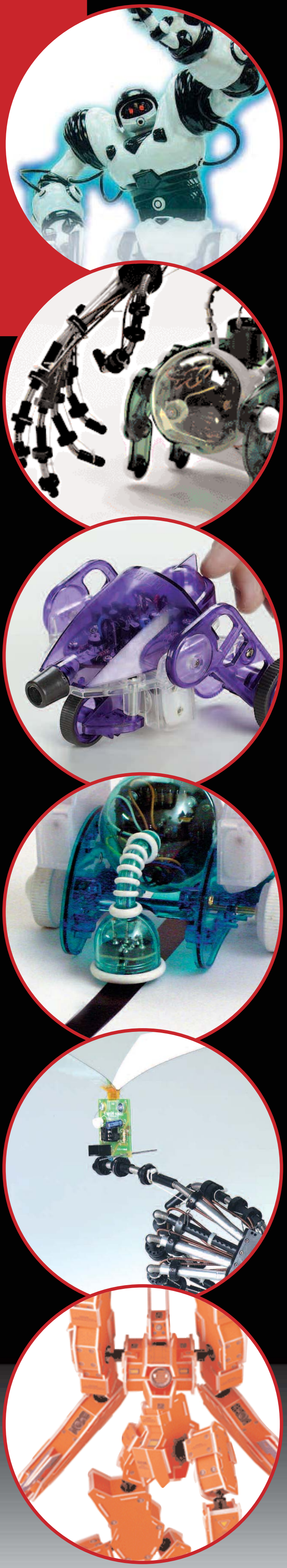
The Carrier 1u can also be used with the Nemesis microcontroller. This microcontroller is faster and has much more memory and capabilities. It would be the next logical step-up if you want to add more functionality.

Be sure to visit the Kronos Robotics website (**www.kronosrobotics.com**) for updates, as well as videos of the rocket launcher in action. ■

PARTS LIST

❑ Athena Microcontroller	Kronos Robotics #16276
❑ Athena Carrier 1u	Kronos Robotics #16425
❑ EZ232 Driver	Kronos Robotics #16167
❑ Red LED	Kronos Robotics #16234
❑ 130 Ohm Speaker	Kronos Robotics #16164
❑ SPST Switch	Kronos Robotics #16241
❑ 10 Segment Bargraph LED	All Electronics #BG-10
❑ Push Button	Jameco #174414CL
❑ 20 Amp Relay	Jameco #134949CL
❑ 2N2222 NPN Transistor	Kronos Robotics #16142
❑ Igniter Clips	RadioShack #270-373
❑ 100 Ohm Resistor	Kronos Robotics #16187
❑ 1K Resistor	Kronos Robotics #16191
❑ Four Cell AA Holder	Kronos Robotics #16323
❑ Athena/Nemesis Compiler	Free download from the Kronos Robotics website.

❑ KRONOS ROBOTICS — www.kronosrobotics.com
❑ JAMECO — www.jameco.com
❑ ALL ELECTROINCS — www.allelectroincs.com



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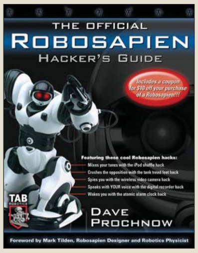
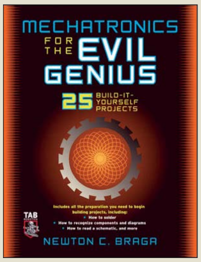
ROBOTICS

The Official Robosapien Hacker's Guide
by Dave Prochnow



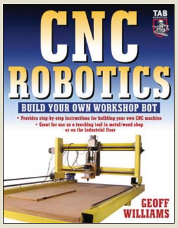
The Robosapien robot was one of the most popular hobbyist gifts of the 2004 holiday season. The brief manual accompanying the robot covered only basic movements and maneuvers — the robot's real power and potential remain undiscovered by most owners — until now! This is the official Robosapien guide — endorsed by WowWee (the manufacturer) and Mark Tilden (the designer). This timely book covers all the possible design additions, programming possibilities, and "hacks"not found anywhere else. **$24.95**

Mechatronics for the Evil Genius
by Newton C. Braga



If you're fascinated by electronics and mechanics, this hands-on tour of the junction where they meet will bring you hours of fun and learning. Noted electronics author Newton Braga's *Mechatronics for the Evil Genius* guides you step by step through 25 complete, intriguing, yet inexpensive projects developed especially for this book. You will build your own mechanical race car, combat robot, ionic motor, mechatronic head, light beam remote control, and 20 other entertaining learning projects that take you to the heart of mechatronics. Each experiment builds on those before it so you develop a hands-on, practical understanding of mechatronics. You don't need to know electronics or mechanics to get started. But by the end, you'll be showing off your own exciting projects! **$24.95**

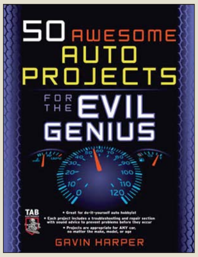
CNC Robotics
by Geoff Williams



Written by an accomplished workshop bot designer/builder, *CNC Robotics* gives you step-by-step, illustrated directions for designing, constructing, and testing a fully functional CNC robot that saves you 80% of the price of an off-the-shelf bot — and can be customized to suit your purposes exactly because you designed it. **$34.95**

AUTOMOTIVE

50 Awesome Auto Projects for the Evil Genius
by Gavin D J Harper

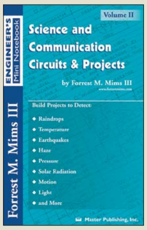


The Evil Genius format is the perfect "vehicle" for 50 incredible automotive projects that are compatible with any car, no matter what make, model, or year. Focusing on low-cost, easily obtained components, *50 Awesome Auto Projects for the Evil Genius* lists the items needed to complete each project along with a troubleshooting and repair section. **$24.95**

ELECTRONICS

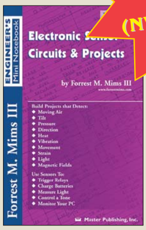
Engineer's Mini Notebook Collection
by Forrest M. Mims III

Volume 1 features more than two dozen 555 timer circuits that you can build. **$12.95**

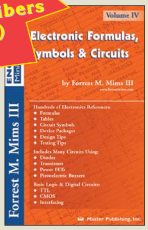


Volume 2 — Study rain, lightning, clouds, sunlight, water, temperature, and much more! **$12.95**

All Four Volumes $46.00 (NV subscribers ONLY!)



Volume 3 — Learn about important sensors and use them to build circuits and projects. **$12.95**



Volume 4 includes frequently used electronic formulas, tables, circuit symbols, and more! **$12.95**

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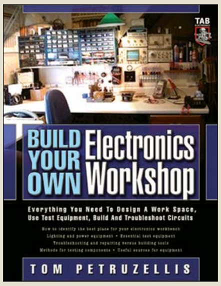
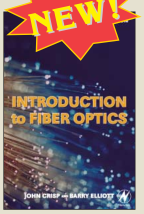
Build Your Own Electronics Workshop
by Thomas Petruzzellis



The Electronics Workbench was created to assist the newcomer in the field of practical electronics through the creation of a personal electronics workbench. It is a place specially designed so that readers can go there to work on an electronic project, such as testing components, troubleshooting a device, or building a new project. The book includes invaluable information, such as whether to buy or build test equipment, how to solder, how to make circuit boards, how to begin to troubleshoot, how to test components and systems, and how to build your own test equipment, complete with appendix & resources, etc. This is *THE* book for anyone entering the field or hobby of electronics. **$29.95**

Introduction to Fiber Optics Third Edition
by John Crisp

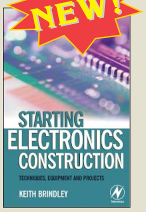
NEW!



Optic fiber and light — a brilliant combination. What makes the light stay in the fiber? The choice of frequency, propagation of light along the fiber, decibels, losses in optic fibers, dispersion and our attempts to prevent it, real cables, connecting optic fibers — the problems, fusion splicing, mechanical splices, connectors, couplers, light sources and detectors, testing a system, system design — or, will it work?, the transmission of signals, designing an optical system and selecting components, LANs and topology, some final thoughts, glossary, and quiz time answers. **$29.95**

Starting Electronics Construction
by Keith Brindley

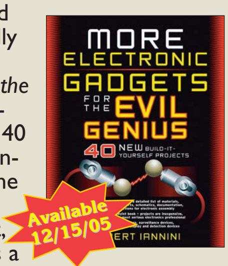
NEW!



This practical electronics book explains how to select the right tools and components for the job, use a soldering iron, etch a printed circuit board, and mount the finished product in a case. While most electronics texts focus on theoretical knowledge, Keith Brindley presents a genuinely 'practical' bench guide and reference for electronics experimenters. The straightforward, interactive style of this book makes it ideal for home electronics work and particularly suitable as an introduction to university lab courses for students who are not familiar with hands-on electronics construction. **$24.95**

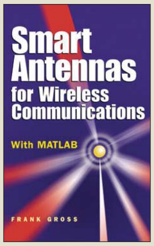
CALL 1-800-783-4624 today! Or Order online @ www.nutsvolts.com

MORE Electronic Gadgets for the Evil Genius
by Robert E. Iannini



This much anticipated follow-up to the wildly popular cultclassic *Electronic Gadgets for the Evil Genius* gives basement experimenters 40 all-new projects to tinker with. Following the tried-and-true Evil Genius Series format, each project includes a detailed list of materials, sources for parts, schematics, documentation, and lots of clear, well-illustrated instructions for easy assembly. The convenient two-column format makes following step-by-step instructions a breeze. Readers will also get a quick briefing on mathematical theory and a simple explanation of operation along with enjoyable descriptions of key electronics topics such as various methods of acceleration, power conditioning, energy storage, magnetism, and kinetics. **$24.95**

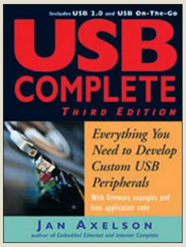
Smart Antennas for Wireless Communications
by Frank Gross



This advanced level text and reference details the operating principles of smart antennas and utilizes a multidisciplinary approach to achieve a more comprehensive understanding of this growing subject. An equal emphasis is placed on electromagnetic principles, array signal processing, random processes, channel characterization, spectral estimation, and adaptive algorithms. The author relates these principles to the real world demands of the wireless communication field. **$99.95**

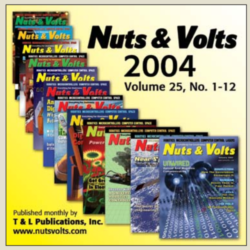
HOME COMPUTING

USB Complete, Third Edition
by Jan Axelson



Every recent PC has Universal Serial Bus (USB) ports. In *USB Complete*, Jan Axelson shows how to design and program devices that use USB to communicate with PCs. Learn how to select a USB controller chip that fits your project and budget, how to write program code to manage USB communications in your device, and how to write Visual Basic .NET and Visual C++ .NET applications that exchange data with your devices. Explore how the interface works from the ground up and learn how to create devices that communicate reliably with all PCs. **$49.95**

Nuts & Volts CD-Rom

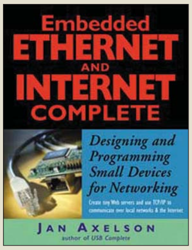


Here's some good news for *Nuts & Volts* readers! Starting with the January 2004 issue of *Nuts & Volts*, all of the issues through the 2004 calendar year are now available on a CD that can be searched, printed, and easily stored. This CD includes all of Volume 25, issues 1-12, for a total of 12 issues. The CD-Rom is PC and Mac compatible. It requires Adobe Acrobat Reader version 6 or above. Adobe Acrobat Reader version 7 is included on the disc. **$29.95**

Winning Results with Google AdWords
by Andrew Goodman

Don't get lost in the digital haystack! With thousands of links for every search, the chances of your products being found online are slimmer than a needle. But there's good news — you can pinpoint your marketing message with help from *Winning Results with Google AdWords*. You'll discover AdWord essentials, how to bid for and win the keywords you want, how to track your results, and much more. Create a profitable ad campaign using online marketing, paid search, targeting, and leveraged branding. **$24.99**

Embedded Ethernet and Internet Complete
by Jan Axelson

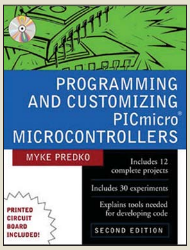


Learn how to design and program devices that host Web pages, send and receive e-mail, and exchange files using FTP. Put your devices on the Internet and monitor and control your devices from across town or around the world. Or create private, local networks that enable your devices to share information, send commands, and receive alarms and status reports. Plus: learn about Ethernet controllers, hardware options for networks, networking protocols, and how to keep your device firmware and data secure. **$49.95**

If you don't see what you need here, check out our online store at www.nutsvolts.com for a complete listing of the titles available.

MICROCONTROLLERS

Programming & Customizing PICMicro Microcontrollers
by Myke Predko

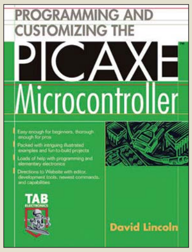


This book is a fully updated and revised compendium of PIC programming information. Comprehensive coverage of the PICMicros' hardware architecture and software schemes will complement the host of experiments and projects making this a true "learn as you go" tutorial. New sections on basic electronics and basic programming have been added for less sophisticated users, along with 10 new projects and 20 new experiments. The CD-ROM contains all source code presented in the book, software tools designed by Microchip and third party vendors for applications, and the complete data sheets for the PIC family in PDF format. **$49.95**

The PIC Microcontroller: Your Personal Introductory Course
by John Morton

Assuming no prior knowledge of microcontrollers and introducing the PIC Microcontroller's capabilities through simple projects, this book is ideal for electronics hobbyists, students, school pupils, and technicians. The step-by-step explanations and the useful projects make it ideal for student and pupil self-study. The revised third edition focuses entirely on the re-programmable Flash PIC microcontrollers such as the PIC16F54, PIC16F84, and the extraordinary eight-pin PIC12F508 and PIC12F675 devices. **$26.95**

Programming and Customizing the PICAXE Microcontroller
by David Lincoln



This beginner-friendly guide from IT pro and PICAXE expert, David Lincoln, shows you just what Revolution Education's PICAXE can do — and helps you make it do it! Packed with ready-to-build projects for all the flavors of PICAXE, the guide provides step-by-step help that's ideal for those just starting out with microcontrollers but also takes more experienced programmers where they need to go fast. Using plenty of examples, *Programming and Customizing the PICAXE Microcontroller* clarifies this versatile chip's basics and coaches you through sophisticated applications. **$39.95**

■ LEVEL RATING: ●●○○ (Intermediate)

THE POOR MAN'S CNC MILLING MACHINE

Wouldn't you love to have a fancy computer-controlled drilling and milling machine so you could make whatever part you needed? Wouldn't you love even more to have the money one of those machines cost? Well, I don't have either, but I do have an occasional need to fabricate a simple part or drill a custom circuit board.

When I finally found some inexpensive linear actuators at an auction, the first thing that popped into my head was CNC (computer numeric control). The machine I came up with has a fairly simple design and is suitable for drilling or cutting simple shapes. With the addition of more horsepower (of the cutting motor variety and the computer control variety), you should end up with a very flexible machine.

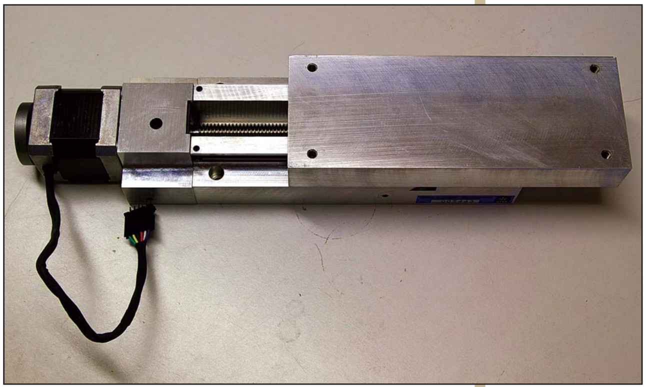
Mechanical Design

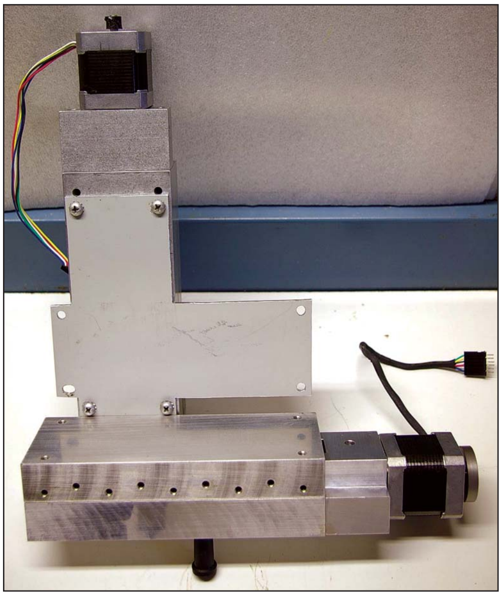
The heart of the Poor Man's CNC is three lead-screw type linear actuators made by Star Linear Systems (Figure 1). The top portion of the actuator is driven back and forth by a unipolar stepper motor and slides on two ball-bearing tracks. The stepper motor has a resolution of 200 steps per revolution (1.8 degrees per step) and the lead screw has a fairly fine thread pitch, so the linear position can be controlled very accurately. I don't have a micrometer, but I would estimate the positioning resolution at less than 0.01 inch. Each actuator has four tapped holes on its top and bottom surfaces, allowing them to be mounted on each other in a three-axis configuration with the fabrication of a couple of simple mounting brackets (Figures 2 and 3).

You may not be able to acquire linear actuators identical to those I used for this project. However, the basic design principles hold for any type of stepper-driven linear actuator you can get your hands on. The more heavy-duty and high-precision the actuator, the more versatile your finished CNC machine will be.

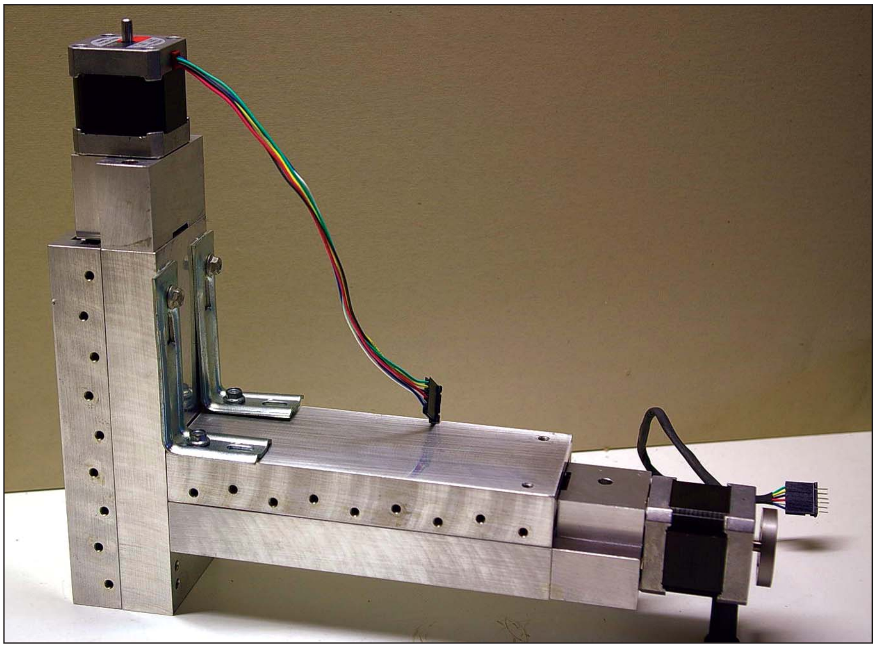
The cutter which will be moved around by the three actuators is an off-the-shelf rotary tool (Dremel or equivalent), fitted with a drill bit or milling bit appropriate for your particular job. These rotary tools are designed to be hand-held, so mounting them securely to the Z-axis linear actuator requires some ingenuity. I settled on using two metal straps (Figure 4), one of them vinyl-coated to prevent the tool from shifting while cutting. This mounting method is simple but has the disadvantage of flexing the body of the rotary tool if you tighten the straps too much, which can misalign the motor bearings inside the tool. If you need very high positioning accuracy and/or expect to put large lateral loads on the cutting bit, I recommend using some sort of

■ FIGURE 1. ONE OF THE LINEAR ACTUATORS. NOTE LEAD SCREW IN MIDDLE.





■ FIGURE 2. MOUNTING PLATE BETWEEN X- AND Y-AXIS ACTUATORS. THE Y-AXIS ACTUATOR IS OFFSET TO HELP BALANCE THE WEIGHT OF THE Z-AXIS ACTUATOR AND ROTARY TOOL.



■ FIGURE 3. TWO LONG L-BRACKETS HOLD THE Y- AND Z-AXIS ACTUATORS TOGETHER AND RAISE THE Z-AXIS ACTUATOR WELL ABOVE THE BASE PLATE.

clamps which can hold the tool securely without flexing it.

The final component of the mechanical design is a rigid base plate which holds the actuator/cutter assembly and the workpiece securely. I used a piece of wood and placed some spacer blocks under the actuator/cutter assembly so the Z-axis actuator and rotary tool would clear the base plate and have a good range of vertical travel. A strip of wood attached to the base plate parallel to the X-axis actuator forms a cleat to which your workpiece can be clamped. The completed mechanical assembly is shown in Figure 5.

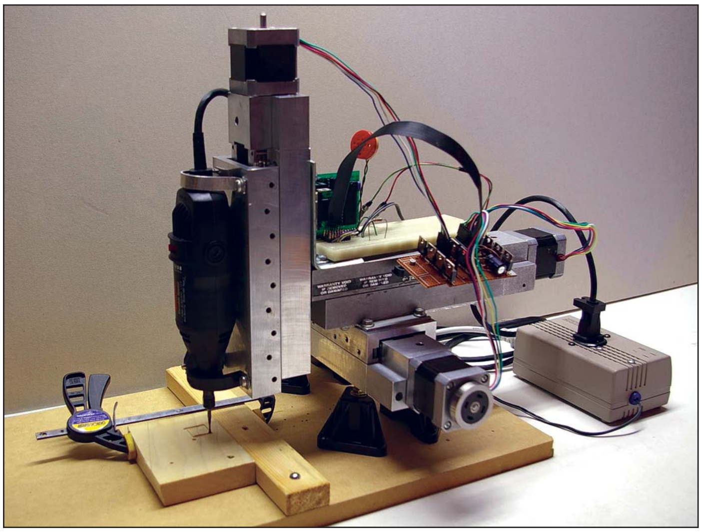
Electronic Design

I selected a BASIC Stamp 2 as the "brain" for the Poor Man's CNC because of the rudimentary cutting and milling tasks I had planned. The BS2 does not do floating-point math, so if you plan to machine complex curves you'll need a more capable microcontroller or desktop PC to drive your CNC machine. On the plus side, the BS2 is very easy to program and interface to the unipolar stepper motors, so you can quickly put together a program to drill an array of holes or cut a simple shape. The BS2 controls the positions of the three linear actuators, turns the rotary tool on and off via a relay, and drives a speaker to provide a warning beep when turning the rotary tool on and off. TIP112 Darlington power transistors are used to drive the four windings in each unipolar stepper motor. These devices have built-in reverse blocking diodes to absorb the voltage spikes created when the motor coils are de-energized. Figure 6 provides the schematic for the BS2-to-stepper motor interface and driver circuit, as well as the relay interface and the piezoelectric speaker. You'll need to build three identical copies of the motor driver circuit in Figure 6, one for each actuator. I recommend installing the relay and all AC wiring in a separate enclosure for safety, as shown in Figure 5.

Programming and Testing

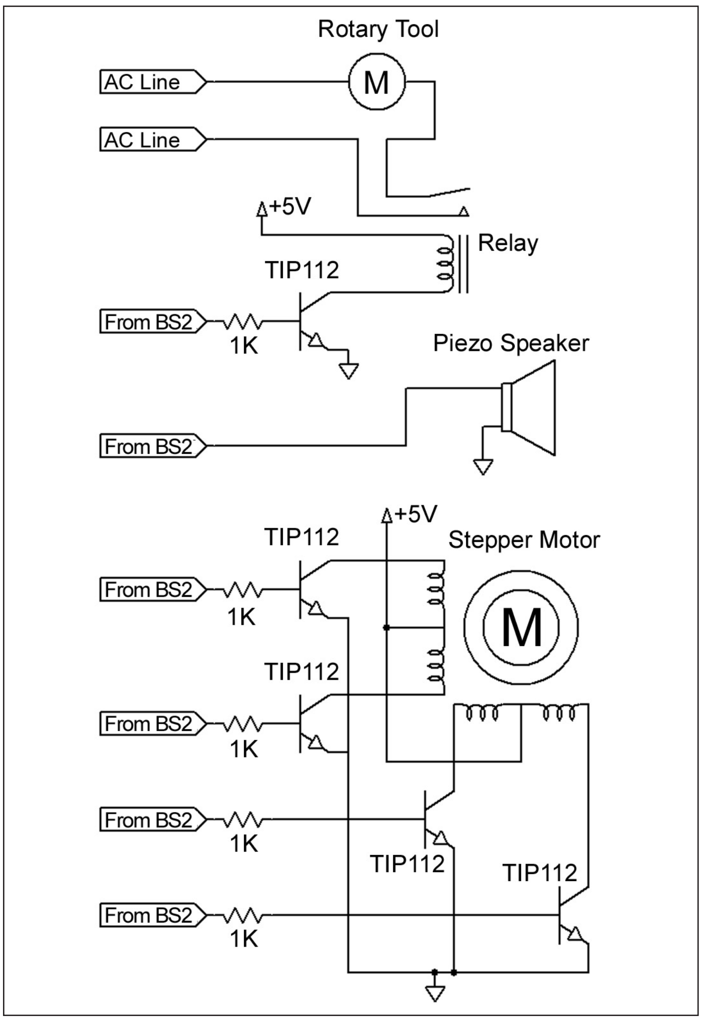
Listing 1 (available on the *Nuts & Volts* website; www.nutsvolts.com) contains a test program to check out your Poor Man's CNC and demonstrate simple motion-

■ FIGURE 4. TWO METAL STRAPS HOLD THE ROTARY TOOL CENTERED ON AND PARALLEL TO THE Z-AXIS ACTUATOR.



■ FIGURE 5. THE COMPLETE ASSEMBLY. NOTE THE MOUNTING POSITION OF THE INTERFACE/DRIVER CIRCUIT BOARD, WHICH ALLOWS GOOD 3-D RANGE OF MOTION WITHOUT STRAINING THE STEPPER MOTOR LEAD WIRES. BOX AT RIGHT CONTAINS THE RELAY AND AC WIRING.

■ FIGURE 6. MOTOR DRIVER CIRCUIT SCHEMATIC.



control code for the BS2. This program will drill a 3 x 3 array of holes in a block of wood. Moving each actuator is as simple as energizing the four stepper motor coils sequentially in the correct pattern, and reversing the direction of motion is accomplished by using a different coil energizing pattern. The OUTA, OUTB, and OUTC commands are used to change the state of all four coils in each motor simultaneously. Stepper motors not in motion at a given time are turned off, as the lead screw assemblies will hold their positions without the stepper motors energized. It may take some trial-and-error to discover the proper coil energizing sequence for your stepper motor. The speed of motion is adjustable by varying the PAUSE length between the OUTx commands.

The test program does not actually turn the stepper motors in one-step increments, but in four-step increments. Each motor has four coils, and a repeating pattern of four OUTx commands is used to produce continuous rotation. This simplifies the programming but reduces the positioning accuracy by a factor of 4. If you need that extra accuracy, your program can issue each of the four OUTx commands separately, but you will need to keep track of which command was sent last so the overall stepping pattern is preserved.

Note that this test program controls the actuator positions in relative terms (i.e., move the X-axis 200 steps from wherever it started out) rather than absolute terms (i.e., move the X-axis from step 0 to step 200). You can easily implement absolute position control by defining an origin (0,0,0) for your coordinate space and counting motor steps in your program — very handy if you plan to make several copies of the same object or drill pattern.

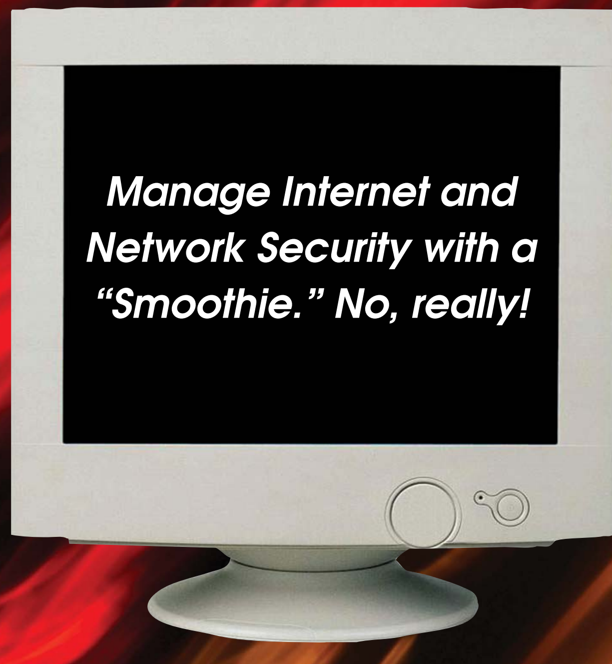
Before you run the test program, manually position the tip of the drill bit in the rotary tool somewhere over the middle of a flat piece of wood, just above the surface of the wood (Are you starting to see the benefits of absolute position control?). When you start the program, the speaker will sound, the rotary tool will spin up to speed, and the first hole will be drilled. Once the last hole is finished, the bit will retract away from the workpiece, the rotary tool will shut off, and the speaker will sound again, telling you to come and admire your fully functional CNC machine. ■

PARTS LIST

- ❑ (3) Linear actuators with five-volt unipolar stepper motors
- ❑ (1) Rotary tool
- ❑ (1) BASIC Stamp II
- ❑ (13) TIP112 Darlington power transistors or equivalent
- ❑ (13) 1K ohm 5% 1/4 watt resistors
- ❑ (1) SPST Relay, five volt coil, contacts rated for 2A/120VAC or better
- ❑ (1) Piezoelectric speaker
- ❑ Miscellaneous wiring, hardware, mounting brackets, Circuit boards, enclosure, etc.

Freeware Linux Hardware Firewall HOW-TO:

HAVE A "SMOOTHIE"



by David Geer

We're about to cover parts and instructions for creating your own Linux hardware firewall using an old box (computer) and the SmoothWall Express 2.0 firewalling software package.

The SmoothWall firewall is an ongoing, Linux-based firewall project that we can expect to be updated and improved on over time. A Linux platform for a firewall is important for several reasons. When coded and tested with expertise and great care, Linux is an extremely stable platform with true multitasking capabilities — more than robust enough to handle firewalling duties. Linux is also still far enough out of the mainstream that few crackers are writing viruses or thinking up attacks against it. Windows-based attacks should not get through nor can they harm the Linux code that makes up the firewall. It is also free because it is open source. And, in this economy, you know everyone loves free!

THE MOST IMPORTANT PART

In the larger picture, what you need most for this build is a healthy concern for computer security. I thought I had security holes beat with software: a software firewall on my laptop itself, anti-virus software for viruses and worms, and anti-spyware for Trojans and a long list of malware. I was wrong. My computer is more invisible to the Web than ever (as tests determined) thanks to what SmoothWall lovers call "the Smoothie."

If you have these other protections and have still gotten malware, or if you felt someone was playing on your box or stealing information, you will appreciate this useful yet inexpensive project. If you want to start out with better than average firewall protection, or want to add a layer to your current security for added peace of mind, this package is for you, too.

As with any good set of instructions, read them entirely before preparing to start your project.

You ready? Okay, then. Let's get 'er done!

PARTS — HARDWARE, SOFTWARE, DOCUMENTATION

You will need an old computer that meets the following minimum system requirements.

- A Pentium compatible processor, 150 MHz or faster
- 32 to (ideally) 64 MB RAM or more
- 2 GB or higher IDE hard drive
- A CD burner (mine was a rebated $20 Polaroid BurnMAX40 CD-R/CD-RW that I installed myself)
- I recommend CDBurner XPPro software, which is free, but you can use whatever you like.
- Video card (during install only)

- Monitor (ditto)
- Keyboard (ditto)

You will need two supported Network Interface Cards (NICs). (See documentation, coming; this is for setup with broadband, which I set up and tested successfully. Setup instructions for use with dial-up are in the documentation, but you'll still need much of what you'll read here to get through it smoothly.)

You will also need two Ethernet cables (Cat5 or better, Cat6, etc., are out now) — no mouse required.

Tools are required — to install a second NIC, you'll need the most basic computer tool kit or a good Phillips screwdriver the right size to take the cover off, etc.

Software is also required, which will need to be burned to a CD and a couple of floppies (Did I mention you need a floppy drive? Well, only if your old computer won't boot from the CD properly), and three PDF documents that can be downloaded from www.smoothwall.org The site also offers free support in the form of forums with very helpful folks posting and responding all over the place.

Here's my topology for this project, which in addition to my Internet service type, will affect how closely my steps and experiences will mirror what you need to do.

Don't get discouraged; between this article, the thorough documentation available from the SmoothWall site (we'll get to that, too), and perhaps some trial and error, you will get through it and come out the other side glad you took the time. You also will be preventing crackers (correct term for bad hackers) from coming in from the other, other side — of your Internet connection.

I connected the firewall to my internal network with the following topology: An ADSL router (some say modem, which isn't technically accurate) — a SpeedStream 5200 to be exact, set in router mode — connected to Alltel DSL service, was then connected via Ethernet to the SmoothWall firewall's first NIC card.

The "Smoothie" was installed on my old HP Pavilion XE736. Ethernet from the second NIC led inbound to my USR 5462 802.11g wireless router, into one of the LAN ports. This was so wireless would work but the router would function like a hub — passing data only. This made IP addressing easier (if you've not done IP addressing, fear not, we're going to guide you through it).

I could then connect via Ethernet back out of a LAN port into my Laptop NIC, or by Wireless to my USR 802.11g USB stick, model 5422. (If you're interested, the two come in a kit from USR, available at TigerDirect.com for about $20 after rebate. If you don't plan to go more than 50 feet from the wireless router, it's an easily configured bargain.)

Oh, and the laptop is an IBM ThinkPad R40 I got from the clearance section at the IBM site (when IBM still owned the division producing the product).

PROCEDURE

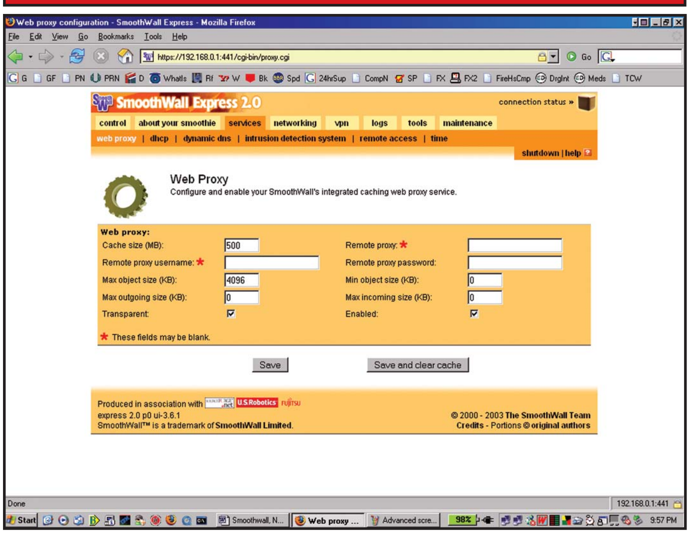
For faster downloading, go to www.smoothwall.org and get the SmoothWall Express 2.0 (final, not beta) and the documentation separately by clicking download, then the larger SmoothWall download link, and then where it says manuals must be downloaded separately.

Burn the software .ISO image to a good CD-RW in such a way as to make it bootable, if possible. If not, you'll need to make and use the two boot floppies, as follows.

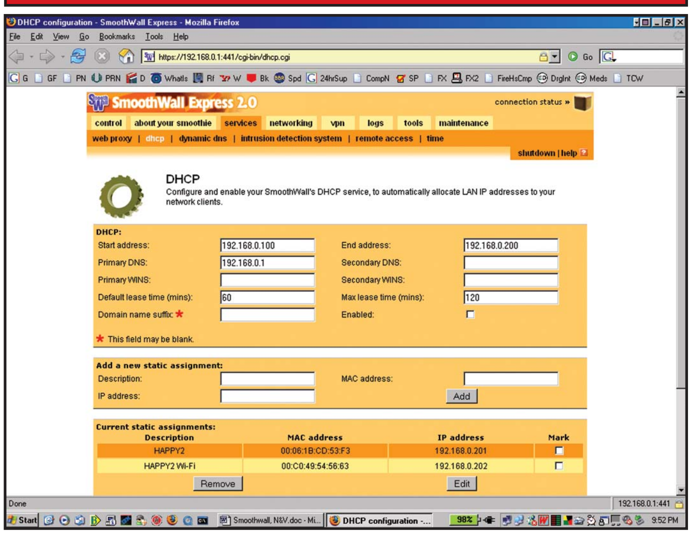
MAKING THE BOOT FLOPPIES

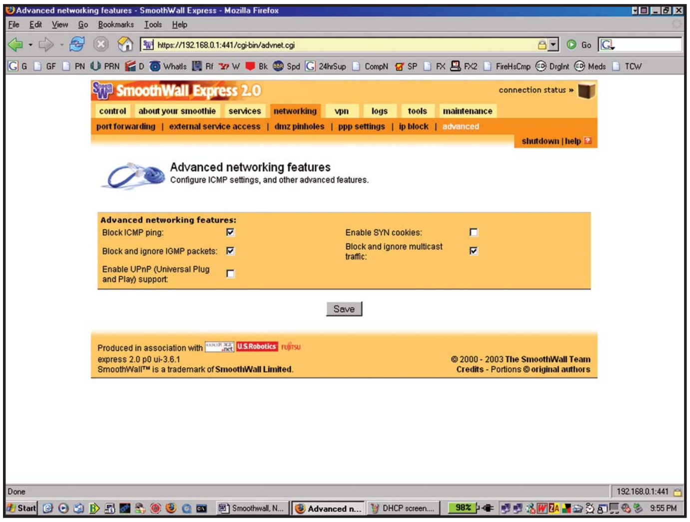
You'll need either your old computer or another one running Windows and a recent Web browser version to get what you need on floppy for the procedure. Don't run the installation on a computer other

■ HERE YOU CAN SET UP A WEB PROXY TO GET AROUND THE OFTEN ATTACKED PORT 80.

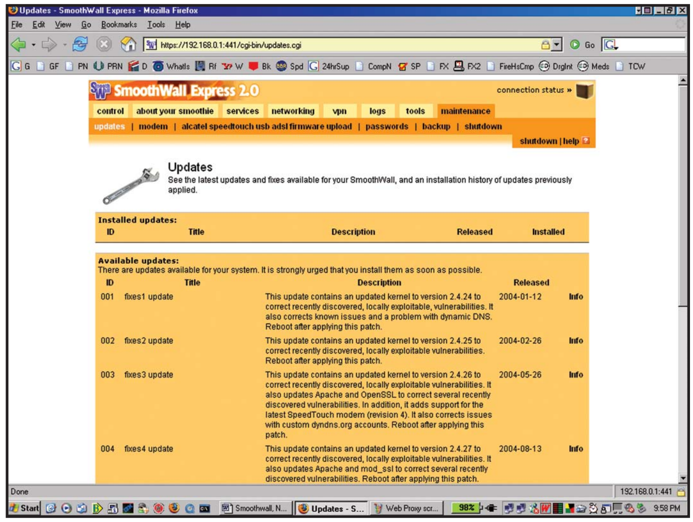


■ HERE YOU CAN SET A RANGE OF IP ADDRESSES TO SERVE TO YOUR COMPUTER OR COMPUTERS, OR DISABLE DHCP AND SET UP STATIC IPs.





■ HERE YOU CAN CHECK TO BLOCK ICMP PINGS, IGMP PACKETS AND MULTICAST, IF YOU SO DESIRE.



■ HERE YOU CAN DOWNLOAD UPDATES, UPLOAD THEM TO YOUR SMOOTHIE, AND THEN HEAD OVER TO SHUTDOWN TO REBOOT.

than your old box. To load SmoothWall, you will need to wipe and use the entire drive. This is done for you, but you don't want it to happen on a computer not entirely set aside for the SmoothWall.

Insert the first of two fully formatted floppies. Insert your new SmoothWall CD, browse, and find the RawWriteWin file in the /dosutils directory. Open it and select the Write tab. Browse to the /images directory and select bootdiskone-2.0.img using the Image file field. Click Write. Don't wash or rinse, but do repeat for the second floppy, loading it with bootdisktwo-2.0.img.

INSTALLING NICS QUICK TUTORIAL

Make sure you know the type of each NIC card and that it is on the compatibility list in the documentation. If it's not on the list, it may work anyway, but better to plan ahead.

Touch metal to discharge the static that could fry your computer. Take the screws out of the back. Take the cover off. Touch some external metal on the back of the computer periodically to discharge static shock. Take your nice new PCI or ISA slot NIC card(s) and pop them gently into the place they belong.

The PCI slot is smaller, and so is the card. Look closely at both. You'll figure it out easily enough. Get it in the slot firmly, but don't go crazy. Screw it into place where the screw hole obviously is at the top. Cover back on, yet? Well, hurry up, let's go!

INSTALLING SMOOTHWALL

From here, you must be on the old computer that you plan to use for

■ Smoothie How-To's Parts Where-To

YOU MAY HAVE OR SHOULD BE ABLE TO PICK UP A WORKING COMPUTER THAT MEETS THESE SPECS FOR NOTHING THESE DAYS:

• A PENTIUM COMPATIBLE PROCESSOR, 150 MHZ OR FASTER.

• 32 TO (IDEALLY) 64 MB RAM OR MORE.

• 2 GB OR HIGHER IDE HARD DRIVE.

• A CD BURNER (YOU CAN GET ONE FROM TIGERDIRECT).

• I RECOMMEND CDBURNER XPPRO SOFTWARE, WHICH IS FREELY AVAILABLE AT WWW.SNAPFILES.COM

• VIDEO CARD (DURING INSTALL ONLY) (ANY COMPATIBLE WITH YOUR PC FROM TIGERDIRECT OR USED).

• MONITOR (DITTO AND DOUBLE DITTO).

• KEYBOARD (DITTO ON THE ... WELL, YOU GET THE IDEA).

• TWO SUPPORTED NETWORK INTERFACE CARDS (SEE DOCUMENTATION, THEN GET 'EM FREE FROM OLD COMPUTERS, OR BUY THE CHEAPEST YOU CAN, OR TRY TIGERDIRECT).

•TWO ETHERNET CABLES (CAT5 OR BETTER, CAT6, ETC., ARE OUT NOW, TRY TIGERDIRECT, OR WALMART OR OFFICEMAX, ETC.).

• MOUSE IS NOT REQUIRED.

your new hardware firewall. You must have a keyboard and monitor connected to it. Boot from carefully labeled floppy one, press Enter to continue, and then feed your computer the second floppy when asked and hit Enter.

Select OK on the next screen (I already had the CD in when I did this). Alt/Tab or arrow keys to CDROM and tab to OK and Enter. It will say insert the CDROM. Do so if not done yet and hit OK. Hit OK again to partition and re-format. Select OK one more time to let the install program know that you're really, really sure (you are, right?).

"In the larger picture, what you need most for this build is a healthy concern for computer security."

You will see it making the root system and then get another screen. Now it's time to Probe (for a NIC for your green interface, that is). This is the NIC that faces in toward your local network. Select Probe, then OK or Skip to find and select the NIC you want to use for your green interface.

The name the install software gives should be close to what you know your NIC is so you should be able to figure it out. Select OK again to use that NIC. Now you need to enter the IP address and subnet mask. As the IP address, you could safely put 192.168.0.1 for a similar configuration to the one I used. The network mask number needs to be 255.255.255.0.

Unless you are familiar with IP addressing, use these exact numbers and don't forget the dots in between. Select OK and it will install the necessary files. After that, you'll be asked to remove the CD and floppy. Do so and select OK.

Select No when asked if you want to restore the configuration from a previous install backup floppy. We'll make the floppy later. For keyboard mapping, select US or your keyboard mapping. Select OK. Use the default SmoothWall hostname and select OK.

If your ISP requires you to use a Web proxy on their network to get the SmoothWall Express updates, find that hostname and port number now and enter those here. Tab to and select OK, whether you need that information or not.

Tab to disable ISDN and then to disable ADSL for this setup. (This ADSL setup on screen is for USB DSL only. If you use ISDN or ADSL with USB, tab through each field and make the most intuitive selections after going over the Quick Start, Install, and Admin PDF documents carefully.)

With our configuration, we are at Network configuration type now. Select that by hitting enter. Arrow to Green + Red and then select OK. Arrow to Drivers and card assignments and select that. Select OK. Probe again. Select OK for the other NIC on your computer. Assign it to Red and tab to and select OK. Select OK again.

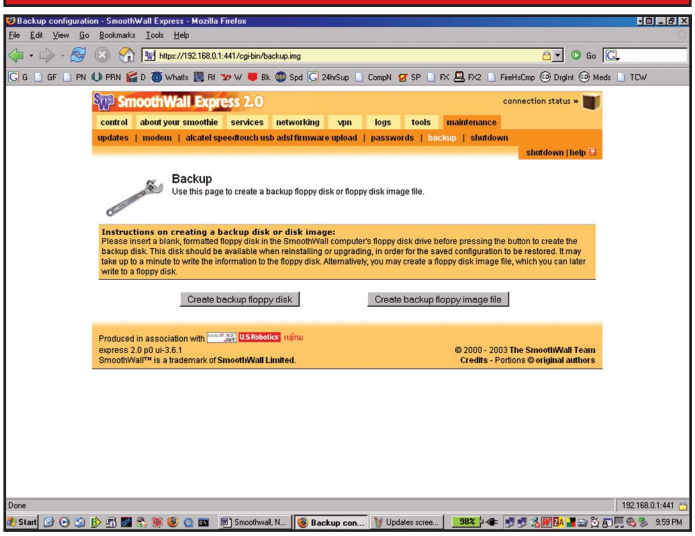
Arrow to address settings. Arrow to red. Select OK. Arrow to DHCP (Dynamic Host Configuration Protocol — automates assigning dynamic Internet Protocol [IP] addresses) and hit the space bar to select it. Leave SmoothWall host name as-is. Tab to OK, leaving the IP address and network mask blank or taking out whatever is there by tabbing there and backspacing. It is best to have everything already plugged in when you do this. Select OK.

Arrow to and select DNS and Gateway settings. You can leave these blank. Select OK and Done. Make sure to be connected as in the topology described earlier. You can easily bypass the Wireless Router if you don't have one and connect straight to your laptop or desktop computer.

Select DHCP server configuration. Hit space bar to enable. For the IP address range, the first IP address should be 192.168.0.100, the same but ending in 200 for the next one, primary DNS, served from the firewall should be 192.168.0.1. No secondary DNS or domain name suffix. The default lease times should be okay. Select OK.

Select root. Select a password and OK. The UID is root and this is your password. Write it down or memorize it in case you need to use the keyboard and monitor again directly on the box to log in to make changes.

■ HERE YOU CAN CREATE A FLOPPY BACK-UP OF YOUR SETTINGS.



Do likewise with setup's UID and Admin's UID. Make all passwords different and unique. Select Quit. If you need to get into setup again, have the keyboard and monitor attached, boot the firewall, and enter setup as your login and your password as your password. No dots appear for the passwords under Linux so you'll have to watch what you type or try again.

You should now be connected through the firewall to the Internet.

FURTHER SETUP VIA WEB INTERFACE (OPTIONAL)

Open up your browser and surf to https://192.168.0.1:441 to connect to port 441 on your Smoothie. To select anything from there, you will have to put in admin and your password in the dialog box that comes up. Here are the settings I use inside. Consider them thoughtfully for your setup.

Go to Services, Web Proxy, check Enabled and click Save. This sets the HTTP port to the proxy setting of 800 instead of 80. It fools some who target port 80 because it is usually wide open.

Go to DHCP. I disabled DHCP and put in static addresses for my NIC and my Wireless USB stick. Save at bottom.

Go to intrusion detection and check Snort and Save. You'll need to check it under logs to see what is attempting to get in.

Go to Advanced under Networking and check the three boxes that start with "Block ... " to be completely invisible to the outside world.

Go to Maintenance and updates and download and install per the instructions all updates starting with one and going through seven (or how ever many there are when you read this) and reboot the firewall after each individual update.

You can also go to backup and create the floppy for restoring configurations when you're all done. Those don't include the settings made only here in the interface, though.

TESTING

Once you can connect to the Internet and get into the browser-based interface to your new Smoothie, you are ready to begin testing your firewall. ShieldsUp (www.grc.com/x/ne.dll?bh0bkyd2) is a great place to start for checking FileSharing and Port vulnerabilities.

When you arrive at the site, click the Proceed button, and the Continue dialog button if it appears. Select the File Sharing button from the menu and then wait for the results. Your results should say that port 139 is invisible and that no NetBios connection could be made.

Scroll down and select the

Common Ports button. You should soon see results that say Passed. Scroll down to see that all your common ports are invisible to the Internet. Select All Service Ports. You will eventually see that the entire grid is green, showing that all service ports are invisible.

Scroll to the bottom of this page and you can check any 64 ports beyond the service ports, one grouping at a time, by selecting User Specified Custom Port Probe and following the clear and simple instructions you'll find there.

FUTURE

Check for updates, though they are rare. Check your logs and see who is NOT getting in. If any attempts are very clearly crackers, you can report them. ■

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DATA Processing Using SCAM(3)

ALGORITHMS & PERFORMANCE

In this article, I adapt some logic and mathematical algorithms for associative processing using my SCAM. I describe how those algorithms are executed in the SCAM in terms of hardware operations. I also show how to calculate the execution time of each algorithm to evaluate the SCAM performance.

ESTIMATING OPERATION COST

Here, I present the deterministic analysis of the execution cost of database queries and different adapted mathematical and logical algorithms. The analysis is based on the elementary operation cost depicted in Tables 1 and 2. I shall use those operations in producing a synthetic formula for query cost in subsequent sections. We assume what is shown in Tables 1 and 2. I chose to set a general estimate of the SCAM's cycle time that is not biased towards a particular technology. The formulas deduced later on refer to the basic operation cost in *units* as a general estimate, which can be scaled or translated to the exact cycle time proven by the implementation.

DATABASE QUERIES

Here, I produce the formulas for evaluating the average cost of queries of different complexities. I decompose queries into their basic modular operations and estimate the

Target attribute position (i.e., sequence) in object	P = 1, 2, 3, ... etc.
Attribute size (in terms of associative words)	S = 1, 2, 3, ... etc.
Word position in attribute (excluding attribute header)	W = 1, 2, 3, ... etc.
Object size (in terms of associative words)	T = 3, 4, 5, ... etc.
Average predicate size (in terms of associative words)	Z >= 0
Average number of forward-processed predicates in the query	F >= 0
Average number of backward-processed predicates in the query	B >= 0
Average number of predicates in the query	I = F + B
Average distance between predicates within object (in terms of fields)	
Average number of qualifying objects	N >= 0

■ TABLE 1. QUERY CALCULATION BASICS

NOTE:

The values between square brackets [] indicate the alternate Comparator setting for the Minimum algorithm. The value outside the brackets indicate the case of Maximum algorithm.

By Gamal Ali Labib

■ TABLE 2. THE COST OF ELEMENTARY OPERATIONS

Operation Description	Code	Cost (Units)
Any command to the Central Control Unit (CCU)	CM	1
Comparing data word/bit in Associative word (Compare) = CM (Write Comparand + Compare) = 2 * CM (Write Comparand + Write Mask + Compare) = 3 * CM	CW1 CW2 CW3	1 2 3
Selecting object header (Set + Compare) = CM + CW	SO	4
Moving activity (link) to next/previous word/field (LNW/LNF/LPW/LPF) = CM	MA	1
Selecting target attribute header (starting from object header) (P * [LNW + LNF + Compare]) = P * [CM + CM + CW_3]	SA	5P
Updating intermediate query-result (Write to Attribute Header) = CM	UF	1
Selecting target word (starting from target attribute header) (W * MA)	SW	W
Selecting target attribute header (starting from target word) (W * MA)	SH	W

cost of each operation based on the SCAM elementary activities previously described. I use the brackets [] to indicate repeated activities within query operations. In some cases, rewriting the Mask may be eliminated, which results in less cost than what is estimated in Examples **a)** through **i)**.

ADAPTED ALGORITHMS

In the second article of this series, I demonstrated the application of the SCAM in querying both simple and complex objects. In doing so, I highlighted the advantage of using the associative techniques in restricting sets of parallel objects. Compared to existing associative processors, the SCAM provides better navigation capabilities, which lead to faster accessibility to object attributes and reduce reliance on storing temporary query results. In this part, I demonstrate the ability of the SCAM to execute logic algorithms, giving it a wider range of applications. The algorithms are: Exact Match, Compare Magnitude with Comparand, and Five-Way Split.

The Exact-Match Algorithm

In this algorithm, we compare each word (W) in the attribute with the corresponding predicate word (I) loaded in the Comparand register. The comparison is done in parallel along all objects in memory. We assume that the result of this operation is to be recorded in a bit (x) within a reserved word in each object. At the end of the comparison cycle, matching attributes will have the Tag bit of their last word set to "1."

An attribute that contains any mismatching word with the predicate will not have any of its Tag bits set to "1" and is discarded from subsequent comparisons. Subsequently, matching objects will have their x-bit set to "1," while other objects will have their x-bit set to "0." Figure 1 illustrates algorithm steps.

<u>Note:</u> The 'discard field' operation is performed by the associative word circuitry, and results in resetting the word's Tag bit to '0.'

Compare Magnitude with Comparand (Three-Way Split Algorithm)

This algorithm determines if a multi-word attribute is "EQUAL-TO," "LESS-THAN," or

■ EXAMPLE A. OBJECT HEADER PROCESSING

Set	Compare (class-ID)	LNW	Compare (class-version ID)	Cost (units)
CM	CW_3	CM	CW_3	8

■ EXAMPLE B. LOCATE THE HEADER OF EACH PREDICATE STARTING FROM CURRENT ATTRIBUTE

Write (Comparator)	Write (Mask)	[LNF]	[Compare] (field-delimiter)	[LNW]	Cost (units)
CM	CM	D*CM	D*CW_1	(D-1)*CW_1	3*D+1

■ EXAMPLE C. LOCATE THE TRAILER OF EACH PREDICATE STARTING FROM ITS HEADER

LNW	LNF	Compare (field-delimiter)	LPW	Cost (units)
CM	CM	CW_1	CM	4

■ EXAMPLE D. COMPARE PREDICATE (FORWARD TRAVERSAL)

Write (Mask)	[Write(Comparator) + Compare(Assoc. Word)]	[LPW]	Cost (units)
CM	Z*CW_2	(Z-1)*CM	3*Z

■ EXAMPLE E. COMPARE PREDICATE (BACKWARD TRAVERSAL)

Write (Mask)	[Write(Comparator) + Compare(Assoc. Word)]	[LPW]	Cost (units)
CM	Z*CW_2	(Z-1)*CM	3*Z

■ EXAMPLE G. LINK-BACK TO ATTRIBUTE-HEADER STARTING FROM CURRENT ATTRIBUTE WORD

LPF	Compare (field-delimiter)	Cost (units)
CM	CW_3	4

■ EXAMPLE F. LINK-BACK TO OBJECT-HEADER STARTING FROM LAST PREDICATE

Write (Comparator)	Write (Mask)	[LPF]	[Compare] (field-delimiter)	[LPW]	Compare (object-header)
CM	CM	I*(D+1)*CM	I*D*CW_1	I*D*CM	CW_3
Cost = I*(3*D+1) + 5 units					

■ EXAMPLE H. RETRIEVE QUALIFYING OBJECTS (FORWARD TRAVERSAL)

Write (Comparator)	Write (Mask)	[LNW]	[Compare] (illegal setting)	Cost (units)
CM	CM	N*T*CM	N*T*CW_1	2*(N*T+1)

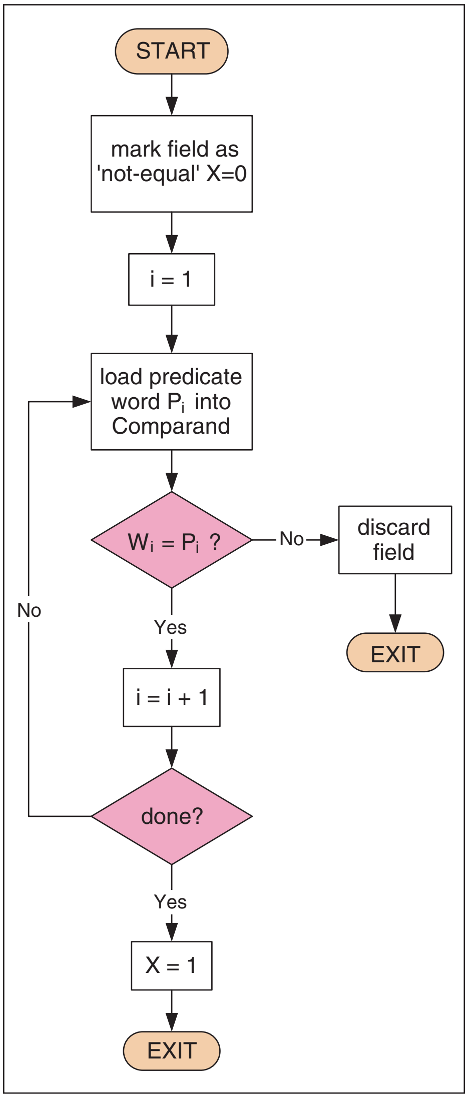
■ EXAMPLE I. RESOLVE A QUERY ON SIMPLE OBJECTS OR CLUSTERED COMPLEX OBJECTS

Process Object Header	I* [Locate Predicate Header]	B* [Locate Predicate Trailer]	F* [Compare Predicate Forward]	B* [Compare Predicate Backward]	Link Back Object Header	Retrieve Qualifying Objects
Cost = 15 + I*(6*D + 3*Z + 2) + 4*B + 2*N*T units						

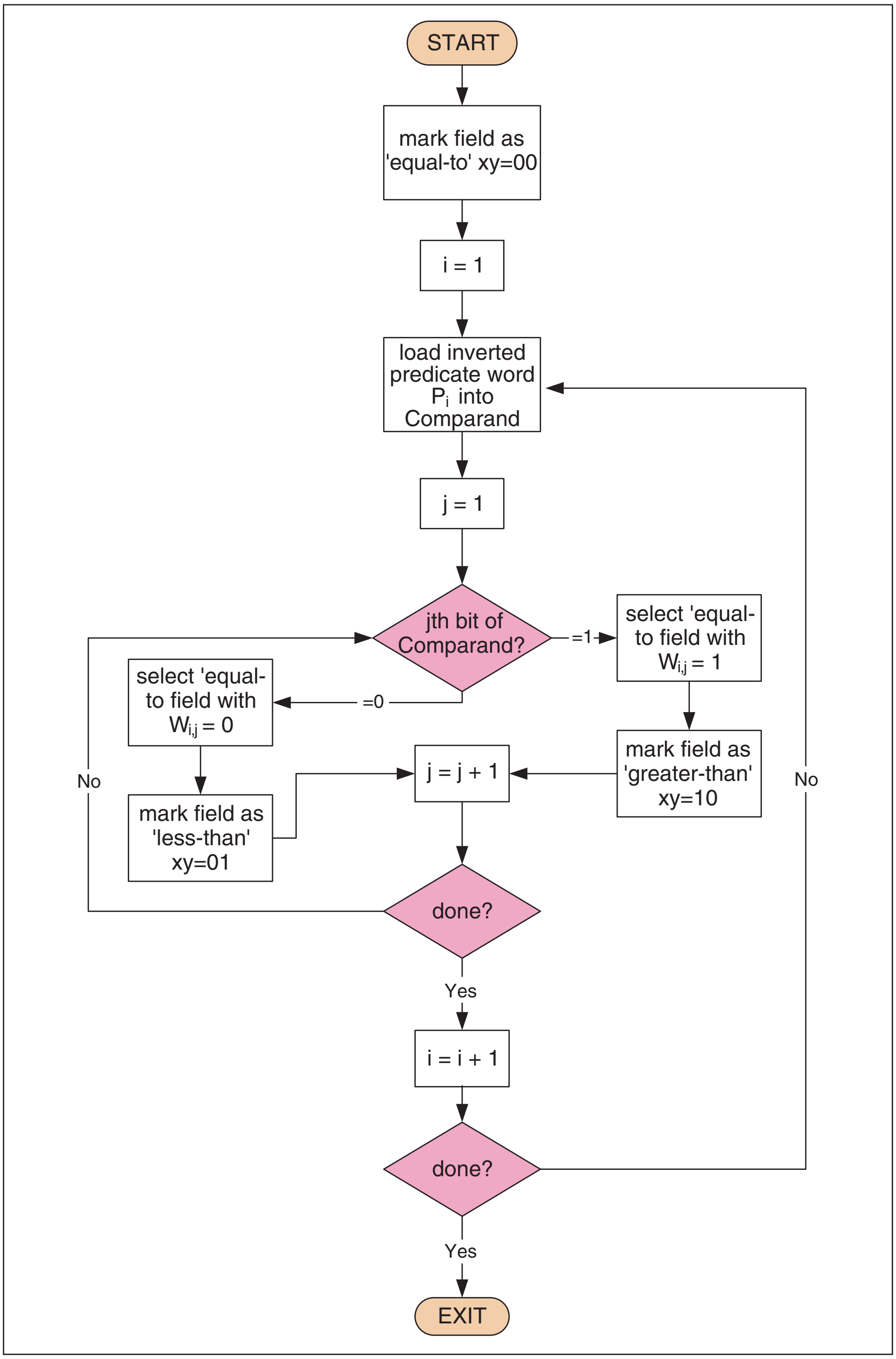
"GREATER-THAN" a given predicate. Each word of the attribute is compared with the corresponding inverted predicate word one bit at a time, using the Mask register to enforce this mode. Here, we assign two bits (x, y) within each object to hold the temporary results of comparisons. Only words of an "EQUAL-TO" attribute are checked against the Comparand. Decided attributes — those marked as "LESS-THAN" or "GREATER-THAN" — are excluded from subsequent checks. The LNW command is used to point to the word due to be checked, while the LPF is used to point back to the result word at the field (i.e., attribute) header. Figure 2 illustrates algorithm steps.

Five-Way Split Algorithm

This algorithm is an extension to



■ FIGURE 1. THE EXACT-MATCH ALGORITHM.



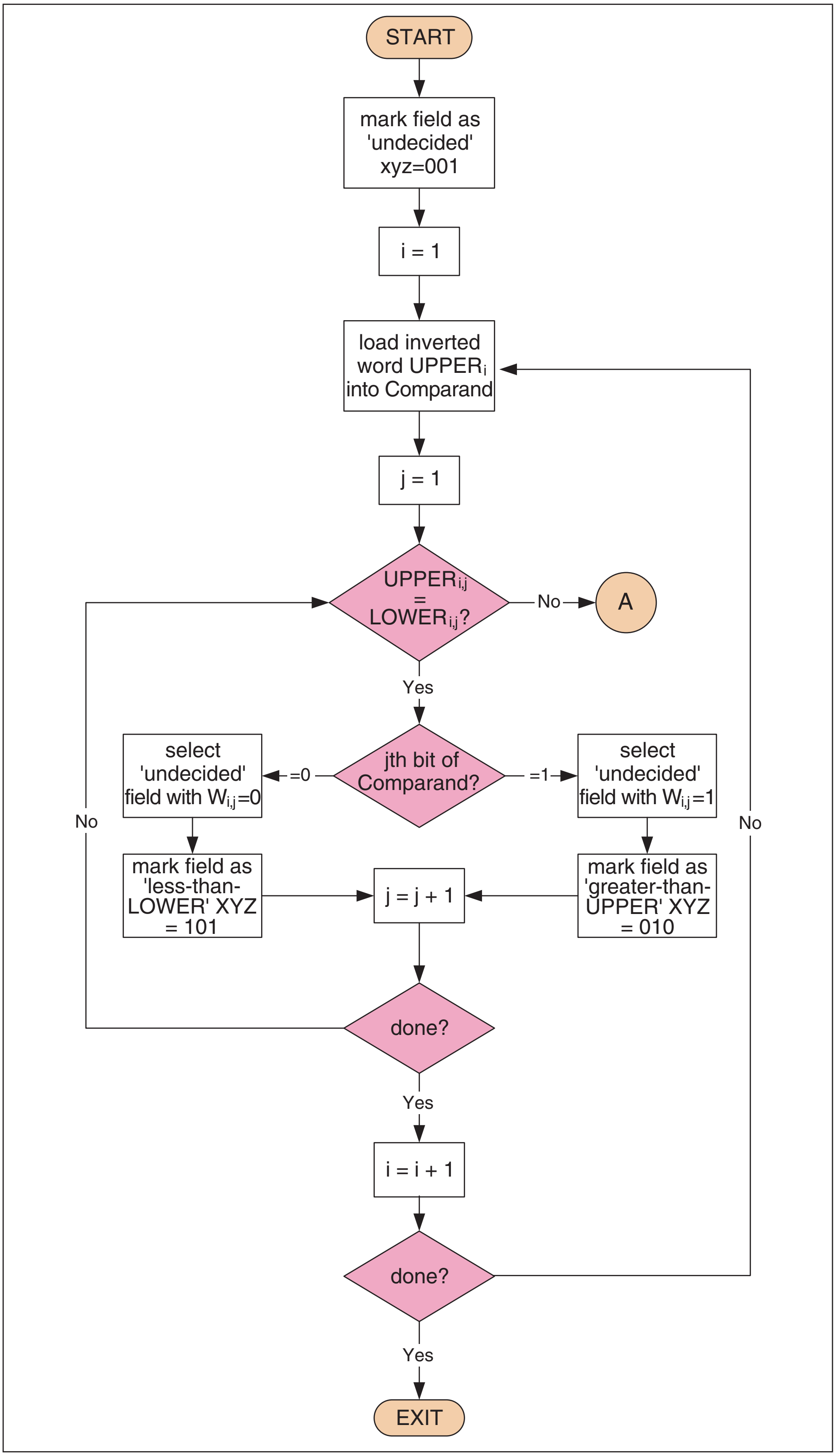
■ FIGURE 2. THREE-WAY SPLIT ALGORITHM.

the Three-Way Split algorithm. Here, we compare the attribute against two boundary values: an upper value and a lower value. In the algorithm, we need to determine if a multi-word attribute is "EQUAL-TO-UPPER," "EQUAL-TO-LOWER," "LESS-THAN-LOWER," "GREATER-THAN-UPPER," or "BETWEEN-UPPER-LOWER." The algorithm (shown in Figures 3, 4, and 5) relies on the SCAM controller to load the inversion of both the upper and the lower boundary values (separately) into the Comparator to determine if the attribute is out of bounds. If Upper and Lower are equal, then the algorithm executes only part-(a) of the illustration in Figure 3.

During execution, attributes with values "> Upper" or "< Lower" are determined and excluded from further checks. When execution ends, "undecided" objects would be "= Upper or Lower." If, however, Upper and Lower differ in any bit setting during part-(a), then execution branches to Figures 4 and 5 until checking the remaining attribute bits is done. Figure 4 marks "undecided" attributes with temporary identification as "near-upper" or "near-lower" if they agree during any bit comparison with the Upper or the Lower values, respectively. Figure 5 makes the final identification of those attributes and produces three results: "LESS-THAN-LOWER," "GREATER-THAN-UPPER," or "BETWEEN-UPPER-LOWER." If the result bits (x, y, z) are maintained in the attribute header word, then the "mark field" operations would have fixed cost, as navigation from any word within an attribute and its header is performed with a single LPF and a Write Data command costing two units.

The "load word" and the "select" operations, on the other hand, are realized by a Write to the Comparand and a Compare command, respectively, costing one unit each. Based on this description, we can make a rough estimate of the cost of this algorithm, which is 12 units for each bit of the predicate, and 12 * (Z * 8) units per query. We excluded the cost of tasks performed by the SCAM controller (e.g., inverting the predicates and keeping track of loop iterations with i, j).

NOTE: ***The 'none' and 'some' states shown in Figure 6 are determined by the RESULT or NONE/SOME signals output from the SCAM device.***

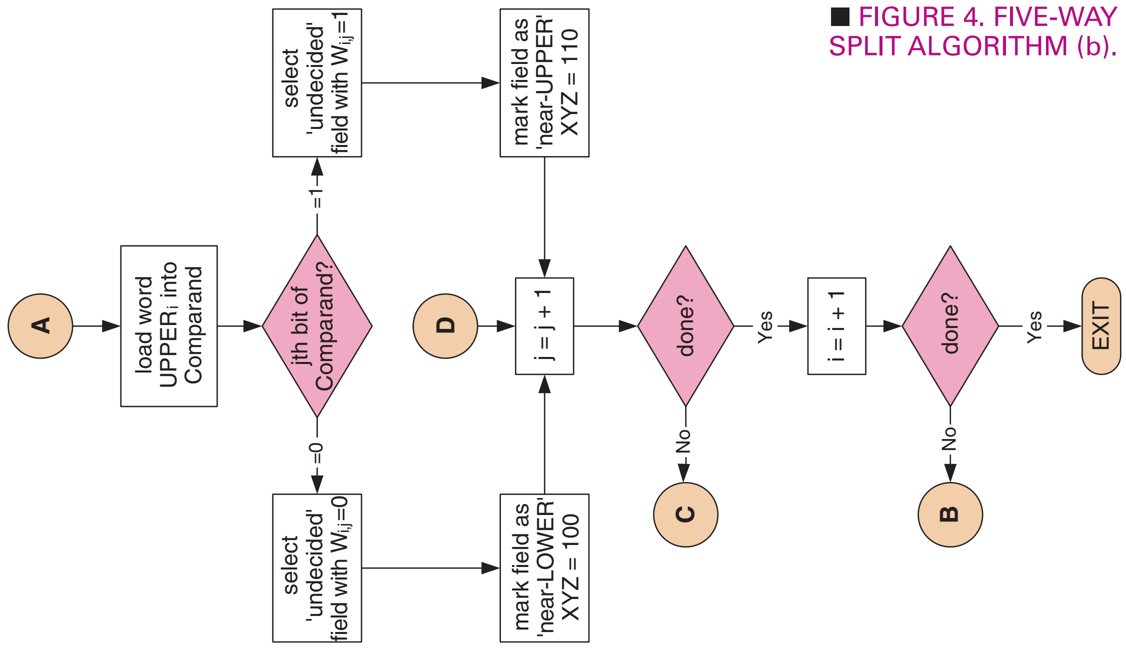


■ FIGURE 3. FIVE-WAY SPLIT ALGORITHM (a).

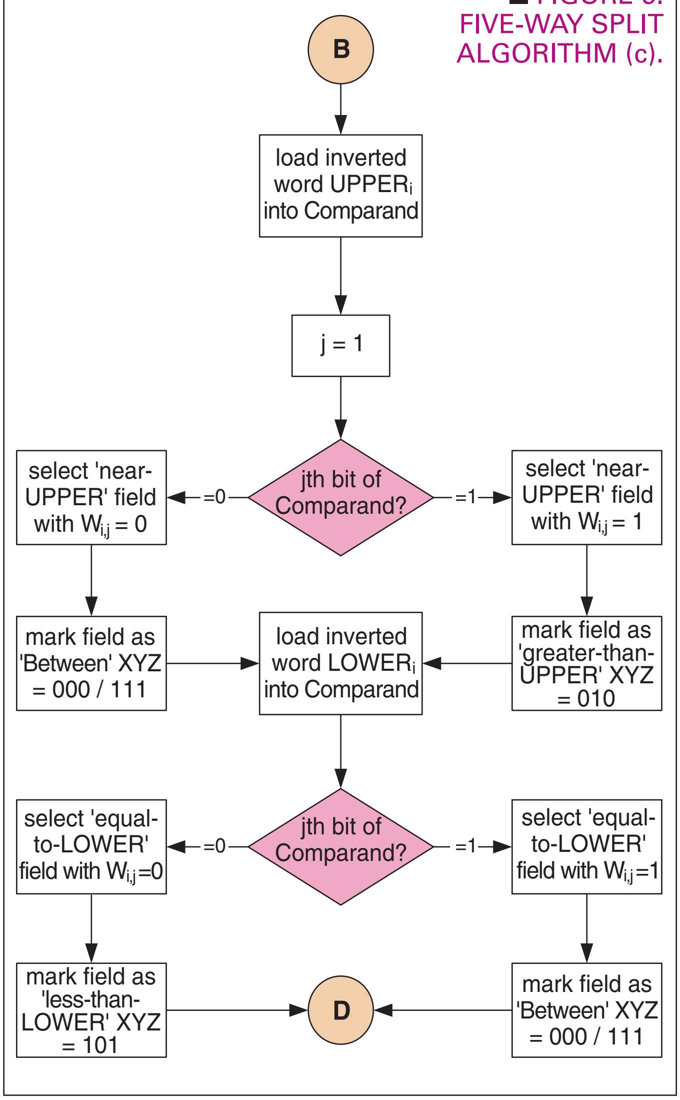
The Maximum-Minimum Algorithm

In this algorithm, we attempt to locate the object(s) with maximum or minimum value for a multi-word attribute. To pick the maximum attribute value, the algorithm compares each bit of the attribute, first with value "1." If any object qualifies, its result bit (x) is left set to "1," while disqualified objects have their x-bit reset to "0" and are discarded from later checks.

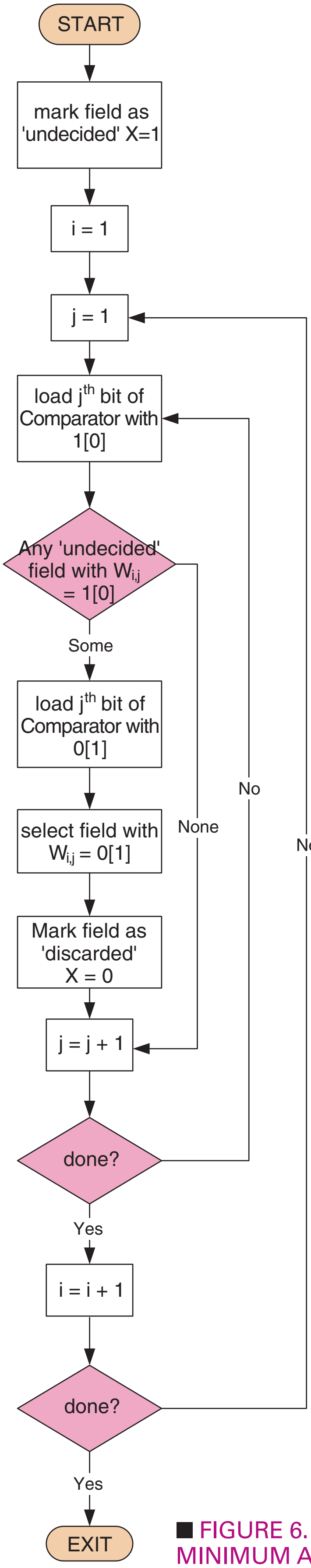
If no object qualifies for a comparison operation, no changes are made to their x-bits. That, in effect, excludes the comparison bit from any selections. At the end of algorithm execution, the object(s) with the maximum value will have the object(s) marked with x-bit = 1. ■



■ FIGURE 4. FIVE-WAY SPLIT ALGORITHM (b).



■ FIGURE 5. FIVE-WAY SPLIT ALGORITHM (c).



■ FIGURE 6. MAXIMUM-MINIMUM ALGORITHM.

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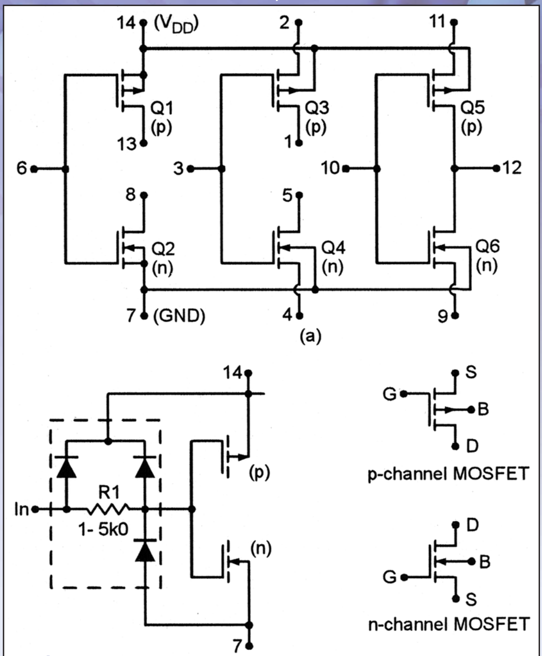
EQUIPMENT

If you are unfamiliar with modern CMOS, the very best way to learn about it is by experimenting with the inexpensive 4007UB IC.

■ FIGURE 1: (A) FUNCTIONAL DIAGRAM OF THE 4007UB DUAL CMOS PAIR PLUS INVERTER. (B) INTERNAL INPUT-PROTECTION NETWORK (WITHIN DOTTED LINES) ON EACH INPUT OF THE 4007UB. (C) MOSFET TERMINAL NOTATIONS; G=GATE, D=DRAIN, S=SOURCE, B=BULK SUBSTRATE.



The 4007UB houses little more than two pairs of complementary MOSFETs and one simple CMOS inverter stage; all of these elements are, however, independently accessible, and can be configured in a variety of ways. The 4007UB is thus a very versatile IC, and is ideal for demonstrating CMOS principles to students, technicians, and engineers. It can readily be configured to act as a multiple digital inverter, a NAND or NOR gate, a transmission gate, or a uniquely versatile 'micropower' linear amplifier or oscillator, etc. This article presents a selection of practical circuits of these types; it starts off, however, by outlining 4007UB basics.

4007UB BASICS

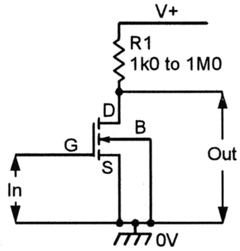
Figure 1(a) shows the functional diagram and pin numbering of the 14-pin 4007UB, which houses two complementary pairs of independently accessible MOSFETs, plus a third complementary pair that is connected in the form of a basic CMOS inverter stage. Each of the three independent input terminals of the IC is internally connected to the standard CMOS protection network shown in Figure 1(b). All MOSFETs in the 4007UB are enhancement-mode devices; Q1, Q3, and Q5 are p-channel types, and Q2, Q4, and Q6 are n-channel types. Figure 1(c) shows the terminal notations of the two MOSFET types; note that the 'B' terminal represents the bulk substrate. All modern '4000B'-series and fast '74'-series CMOS ICs are designed around the basic elements shown in Figure 1, and it is thus useful to get a good basic understanding of both the digital and the linear characteristics of these elements, starting off with those of the basic MOSFETs.

DIGITAL OPERATION

The input (gate) terminal of a MOSFET presents a near-infinite impedance

By Ray Marston

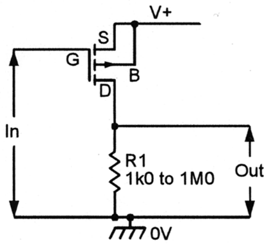
FIGURE 2



In	Out
0	1
1	0

■ FIGURE 2: DIGITAL INVERTER MADE FROM N-CHANNEL MOSFET.

FIGURE 3



In	Out
0	1
1	0

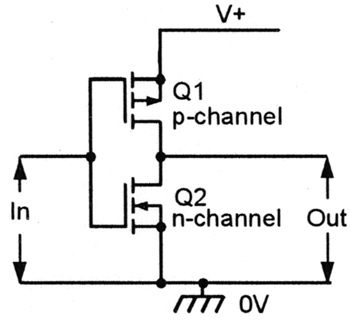
■ FIGURE 3: DIGITAL INVERTER MADE FROM P-CHANNEL MOSFET.

to DC voltages, and the magnitude of an external voltage applied to the gate controls the magnitude of the MOSFET's source-to-drain current flow. The basic characteristics of the enhancement-mode n-channel MOSFET are such that the source-to-drain path is open circuit when the gate is at the same potential as the source, but becomes a near short-circuit (a low-value resistance) when the gate is heavily biased positive to the source. Thus, the n-channel MOSFET can be used as a digital inverter by wiring it as shown in Figure 2; with a logic-0 (zero volts) input, the MOSFET is cut off and the output is at logic-1 (the positive rail voltage), but with a logic-1 input, the MOSFET is driven on and the output is at logic-0.

The basic characteristics of the enhancement-mode p-channel MOSFET are such that the source-to-drain path is open when the gate is at the same potential as the source, but becomes a near-short when the gate is heavily biased negative to the source. The p-channel MOSFET can thus be used as a digital inverter by wiring it as shown in Figure 3.

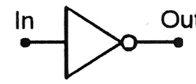
Note in the Figure 2 and 3 inverter circuits that the ON currents of the MOSFETs are determined by the R1 value, and these circuits thus draw a significant quiescent current when their MOSFETs are driven ON. This snag can be overcome by connecting the complementary pair of MOSFETs in the classic CMOS inverter configuration shown in Figure 4(a).

FIGURE 4



In	Out
0	1
1	0

(b)



(c)

■ FIGURE 4: (A) CIRCUIT, (B) TRUTH TABLE, AND (C) STANDARD SYMBOL OF THE CMOS DIGITAL INVERTER.

In Figure 4(a), with a logic-O input applied, Q1 is driven fully on and the output is thus firmly tied to the logic1 (positive rail) state, but Q2 is cut off and the inverter thus passes zero quiescent current via this MOSFET. With a logic-1 input applied, Q2 is driven on and the output is firmly tied to the logic-0 (zero volt) state, but Q1 is cut off and the circuit again passes zero quiescent current. This 'zero quiescent current' characteristic of the complementary MOSFET inverter is one of the most important features of the CMOS digital inverter, and the Figure 4(a) circuit forms the basis of the entire CMOS family of digital ICs. Q5 and Q6 of the 4007UB are fixed-wired in this CMOS inverter configuration.

LINEAR OPERATION

To fully understand the operation and vaguaries of CMOS circuitry, it is necessary to understand the linear characteristics of basic MOSFETs. Figure 5 shows the typical gate-voltage/drain-current graph of an n-channel enhancement mode MOSFET. Note that negligible drain current flows until the gate voltage rises to a 'threshold' value of about 1.5 to 2.5 volts, but that the drain current then increases almost linearly with further increases in gate voltage.

Figure 6 shows how to connect an n-channel 4007UB MOSFET as a linear inverting amplifier. R1 serves as the drain load of Q2, and R2-Rx bias the gate so that the device operates in the linear mode. The Rx value must be selected to give the desired quiescent drain voltage, but is normally in the range 18K to 100K. The amplifier can be made to give a very high input impedance by wiring a 10M isolating resistor between the R2-Rx junction and the gate of Q2, as shown in Figure 6(b).

Figure 7 shows the typical ID/VDS characteristics of an n-channel MOSFET at various fixed values of gate-to-source voltage. Imagine here that, for each set of curves, VGS is fixed at the VDD volt-

■ FIGURE 5: TYPICAL GATE-VOLTAGE/DRAIN-CURRENT CHARACTERISTICS OF AN N-CHANNEL MOSFET.

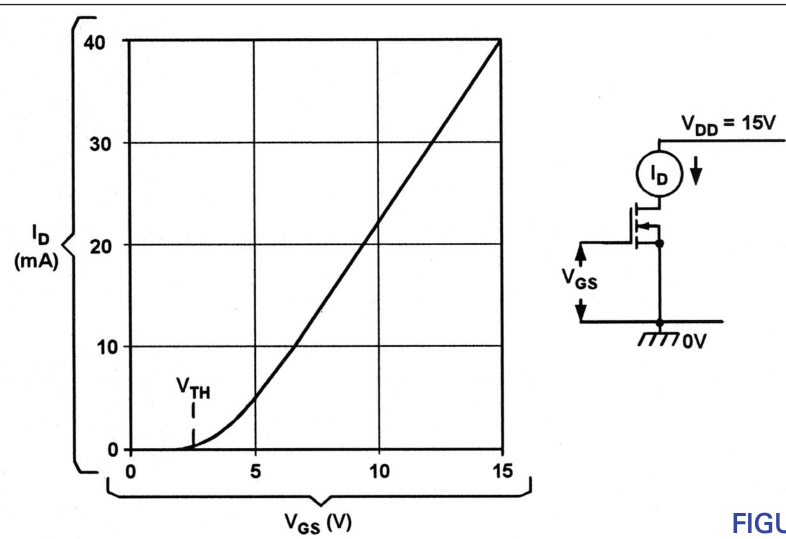
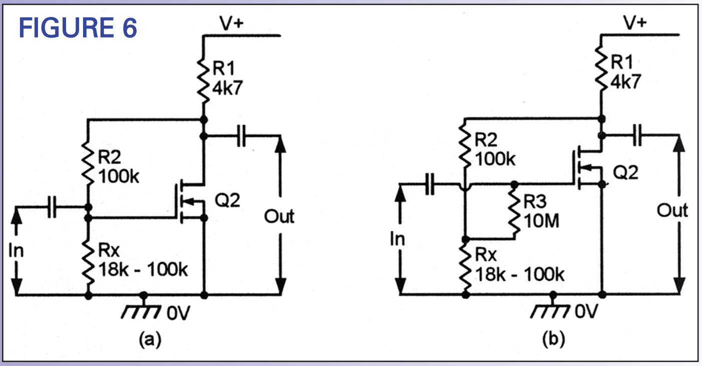
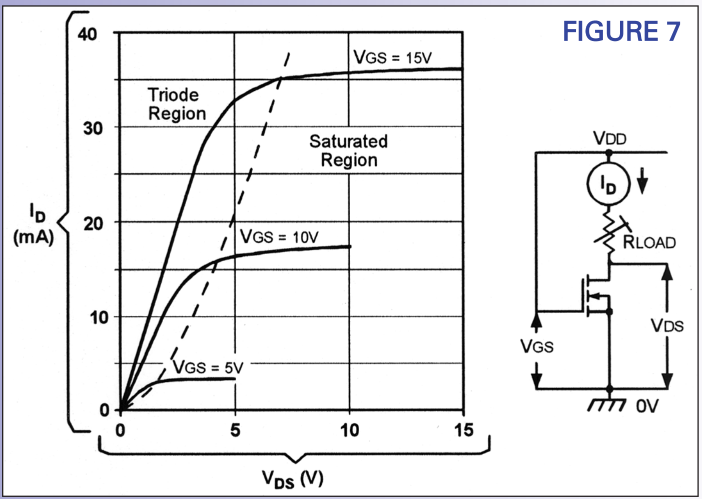


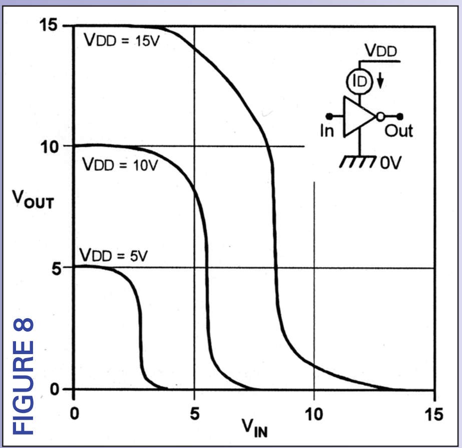
FIGURE 5



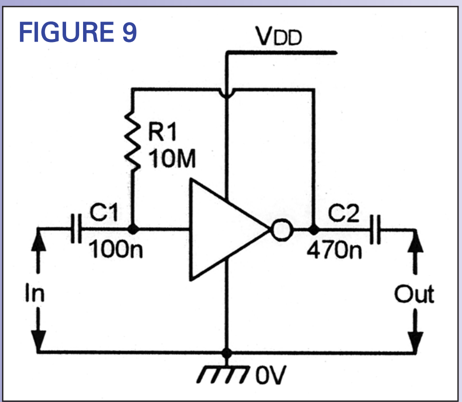
■ FIGURE 6: METHODS OF BIASING AN N-CHANNEL MOSFET AS A LINEAR INVERTING AMPLIFIER.



■ FIGURE 7: TYPICAL ID TO VDS CHARACTERISTICS OF THE N-CHANNEL MOSFET AT VARIOUS FIXED VALUES OF VGS.



■ FIGURE 8: TYPICAL VOLTAGE TRANSFER CHARACTERISTICS OF THE 4007UB SIMPLE CMOS INVERTER.



■ FIGURE 9: METHOD OF BIASING THE SIMPLE CMOS INVERTER FOR LINEAR OPERATION.

age, but that the VDS output voltage can be varied by altering the value of drain load RL. The graph can be divided into two characteristic regions, as indicated by the dotted line; these being the triode region and the saturated region.

When the MOSFET is in the saturated region (with VDS at some value in the nominal range 50 to 100 percent of VGS), the drain acts like a constant current source, with its current value controlled by VGS: a low VGS value gives a low constant-current value, and a high VGS value gives a high constant-current value. These saturated constant-current characteristics provide CMOS with an output 'short-circuit proof' feature and also determine its operating speed limits at different supply voltage values.

When the MOSFET is in the triode region (with VDS at some value in the nominal range 1 to 50 percent of VGS), the drain acts like a voltage-controlled resistance, with the resistance value increasing approximately as the square of the VGS value.

The p-channel MOSFET has an ID/VDS characteristics graph that is complementary to that of Figure 7. Consequently, the action of the basic CMOS inverter of Figure 4 (which uses a complementary pair of MOSFETs) is such that its current-drive capability into an external load — and also its operating speed limits — increase in proportion to the supply rail voltage.

Figure 8 shows the typical voltage-transfer characteristics of the 4007UB's standard CMOS inverter at different supply voltage values. Note (on the 15V VDD line, for example) that the output voltage changes by only a small amount when the input voltage is shifted around the VDD and 0V levels, but that when Vin is biased at roughly half-supply volts, a small change of input voltage causes a large change of output voltage; typically, the inverter gives a voltage gain of about 30 dB when used with a 15 volt supply, or 40 dB at five volts. Figure 9 shows how to connect the CMOS inverter as a linear amplifier; the circuit has a typical bandwidth of 710 kHz at five volts supply, or 2.5 MHz at 15 volts.

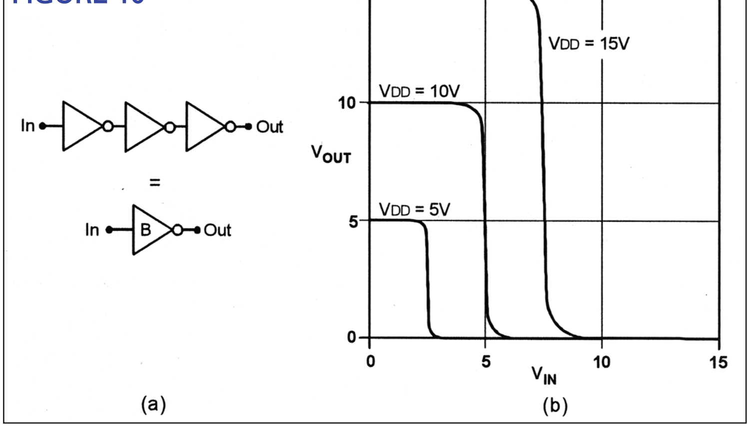
Wiring three simple CMOS inverter stages in series as in Figure 10(a) gives the direct equivalent of a modern '4000B'-series 'buffered' CMOS inverter stage, which has the overall voltage transfer graph of Figure 10(b). The B-series inverter typically gives about 70 dB of linear voltage gain, but tends to be grossly unstable when used in the linear mode.

Finally, Figure 11 shows the drain-current transfer characteristics of the simple CMOS inverter. Note that the drain current is zero when the input is at either zero of full supply volts, but rises to a maximum value (typically 0.5 mA at 5V supply, or 10.5 mA at 15V supply) when the input is at roughly half-supply volts, under which condition both MOSFETs of the inverter are biased on. In the 4007UB, these ON currents can be reduced by wiring extra resistance in series with the source of each MOSFET of the CMOS inverter; this technique is used in the 'micropower' circuits shown later in this article.

USING THE 4007UB

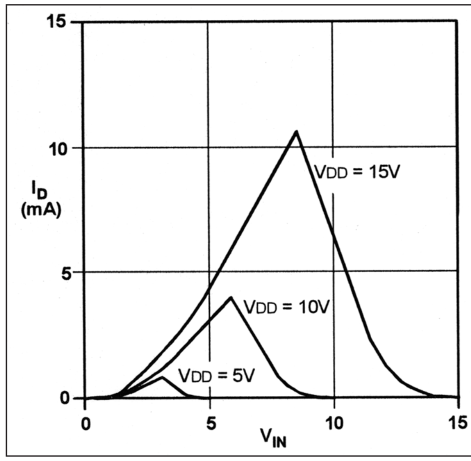
The 'usage' rules of the 4007UB are quite simple. In any specific application, all unused elements of the device must be disabled; complementary pairs of MOSFETs can be disabled by connecting them as standard CMOS inverters and tying their inputs to ground, as shown in Figure 12; in-

FIGURE 10



■ FIGURE 10: WIRING THREE SIMPLE CMOS INVERTERS IN SERIES (A) GIVES THE EQUIVALENT OF A B-SERIES ‘BUFFERED’ CMOS INVERTER, WHICH HAS THE TRANSFER CHARACTERISTICS SHOWN IN (B).

FIGURE 11



■ FIGURE 11: DRAIN-CURRENT TRANSFER CHARACTERISTICS OF THE SIMPLE CMOS INVERTER.

dividual MOSFETs can be disabled by tying their source to their substrate (B) and leaving the drain open circuit.

In use, the input terminals must not be allowed to rise above VDD (the positive supply voltage) or below VSS (zero volts). To use an n-channel MOSFET, the source must be tied to VSS, either directly or via a current-limiting resistor. To use a p-channel MOSFET, the source must be tied to VDD, either directly or via a current-limiting resistor.

PRACTICAL CIRCUITS — DIGITAL

The 4007UB elements can be configured to act as any of a variety of standard digital circuits. Figure 13 shows how to wire the IC as a triple inverter, using all three sets of complementary MOSFET pairs. Figure 14 shows the connections for making an inverter plus non-inverting buffer; here, the Q1-Q2 and Q3-Q4 inverter stages are simply wired directly in series, to give an overall non-inverting action.

The maximum source and sink output currents of a simple CMOS inverter stage self-limit at about 10-20 mA as one or other of the output MOSFETs turns fully on. Higher sink currents can be obtained by simply wiring n-channel MOSFETs in parallel in the output stage. Figure 15 shows the 4007UB wired so that it acts as a high-sink-current inverter that will absorb triple the current of a normal inverter. Similarly, Figure 16 shows how to wire the 4007UB to act as a high-source-current inverter, and Figure 17 shows the connections for making a single inverter that will sink or source three times more current than a standard inverter stage.

The 4007UB is an ideal device for demonstrating basic CMOS logic gate principles. Figure 18 shows it used for making a two-input NOR gate; note that the two n-channel MOSFETs are wired in parallel so that either can pull the output to ground from a logic-1 input, and the two p-channel MOSFETs are wired in series so that both must turn on to pull the output high from a logic-0 input. The Truth Table shows the logic of the circuit. A three-input NOR gate can be made by simply wiring three p-channel MOSFETs in series and three n-channel MOSFETs in parallel, as shown in Figure 19.

Figure 20 shows the 4007UB used as a two-input NAND gate, with the two p-channel MOSFETs wired in parallel and the two n-channel MOSFETs wired in series. A three-input NAND gate can be made by similarly wiring three p-channel MOSFETs in parallel and three n-channel MOSFETs in series.

Figure 21 shows the basic way of using the 4007UB to make another important CMOS element — the trans-

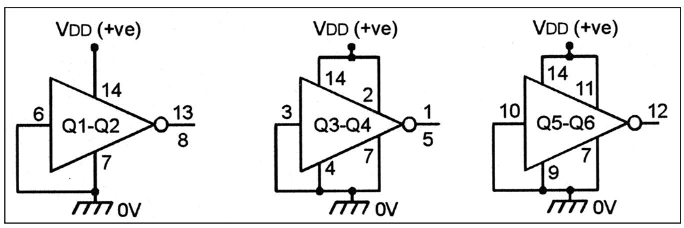
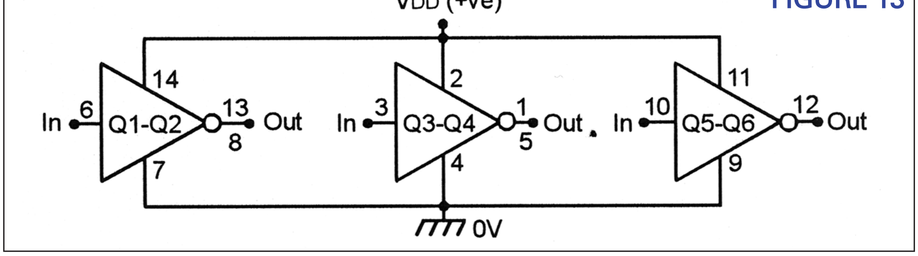


FIGURE 12

FIGURE 13



■ FIGURE 12: INDIVIDUAL 4007UB COMPLEMENTARY MOSFET PAIRS CAN BE DISABLED BY CONNECTING THEM AS CMOS INVERTERS AND GROUNDING THEIR INPUTS.

■ FIGURE 13. 4007UB TRIPLE INVERTER.

■ FIGURE 14: 4007UB INVERTER PLUS NON-INVERTING BUFFER.

FIGURE 14

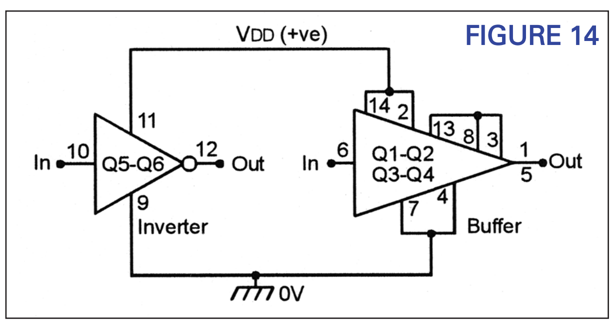


FIGURE 15

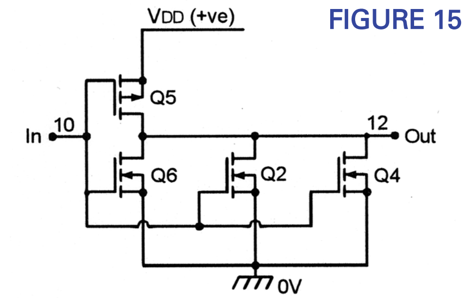


FIGURE 16

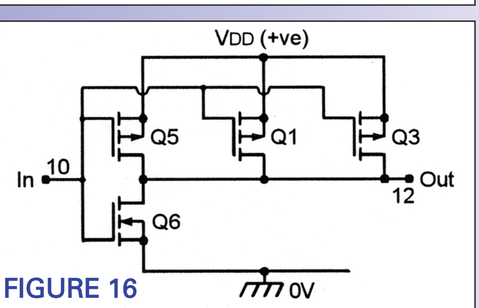


FIGURE 17

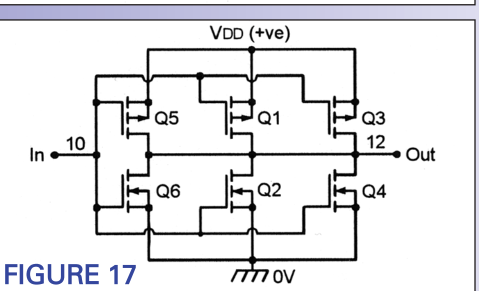
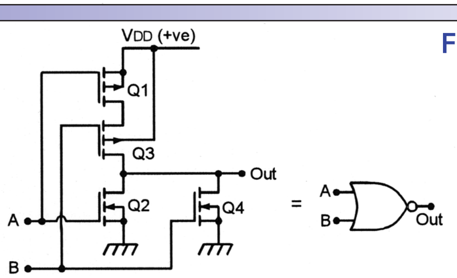


FIGURE 18



A	B	Out
0	0	1
0	1	0
1	0	0
1	1	0

FIGURE 19

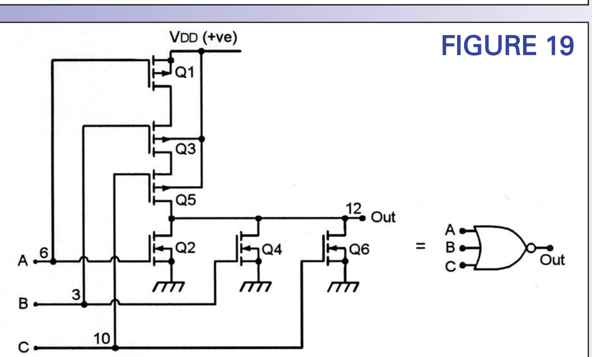
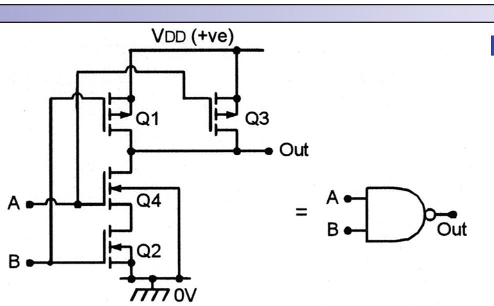


FIGURE 20



A	B	Out
0	0	1
0	1	1
1	0	1
1	1	0

■ FIGURE 15: 4007UB HIGH-SINK-CURRENT INVERTER.

■ FIGURE 16: 4007UB HIGH-SOURCE-CURRENT INVERTER.

■ FIGURE 17: 4007UB HIGH-POWER INVERTER, WITH TRIPLE THE SINK- AND SOURCE-CURRENT CAPABILITY OF A STANDARD INVERTER.

■ FIGURE 18: 4007UB TWO-INPUT NOR GATE.

■ FIGURE 19: 4007UB THREE-INPUT NOR GATE.

■ FIGURE 20: 4007UB TWO-INPUT NAND GATE.

mission gate or bilateral switch — which acts like a near-perfect switch that can conduct signals in either direction and can be turned on (closed) by applying a logic-1 to its control terminal or turned off (open) via a ogic-0 control signal. In Figure 21, an n-channel and a p-channel MOSFET are wired in parallel (source-to-source and drain-to-drain), but their gate signals are applied in anti-phase via the Q1-Q2 inverter. To turn the Q3-Q6 transmission gate on (closed), Q6 gate is taken to logic-1 and Q3 gate to logic-0 via the inverter; to turn the switch off, the gate polarities are simply reversed. The 4007UB transmission gate has a near-infinite OFF resistance and an ON resistance of about 600R. It can handle all signals between zero volts and the positive supply rail value. Note that, since the gate is bilateral, either of its main terminals can function as an input or output.

Finally, Figure 22 shows how the 4007UB can be wired as a dual transmission gate that functions like a single-pole double-throw (SPDT) switch. In this case, the circuit uses two transmission elements, but their control voltages are applied in anti-phase, so that one switch opens when the other closes, and vice versa. The 'X' sides of the two gates are shorted together to give the desired SPDT action.

PRACTICAL CIRCUITS — LINEAR

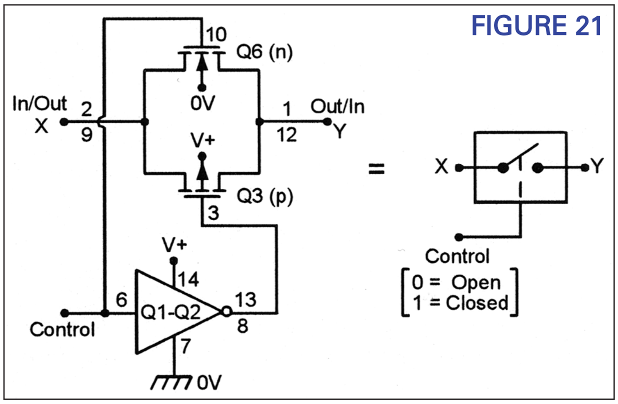
Figures 6 to 9 have already shown that the basic 4007UB MOSFETs and the CMOS inverter can be used as linear amplifiers. Figure 23 shows the typical voltage gain and frequency characteristics of the linear CMOS inverter when operated from three alternative supply rail values (this graph assumes that the amplifier output is feeding into the high impedance of a 10M/15pF oscilloscope probe). The output impedance of the open-loop amplifier typically varies from 3.0K at 15 volts supply, to 5.0K at 10 volts, or 22K at five volts, and it is the product of the output impedance and output load capacitance that determines the bandwidth of the circuit; increasing the output impedance or load capacitance reduces the bandwidth.

As you would expect from the voltage transfer graph in Figure 8, the distortion characteristics of the CMOS linear amplifier are not very good. Linearity is fairly good for small-amplitude signals (output amplitudes up to three volts pk-to-pk with a 15V supply), but the distortion then increases progressively as the output approaches the upper and lower supply limits. Unlike a bipolar transistor circuit, the CMOS amplifier does not 'clip' excessive sine wave signals, but progressively rounds off their peaks.

Figure 24 shows the typical drain-current/supply-voltage characteristics of the basic CMOS linear amplifier. Note that the supply current typically varies from 0.5 mA at five volts to 12.5 mA at 15 volts.

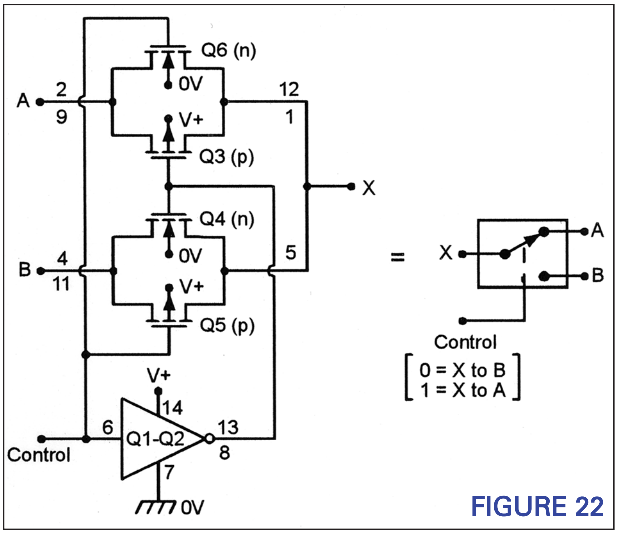
'MICROPOWER' CIRCUITS

In many applications, the quiescent supply current of the 4007UB CMOS linear amplifier can be usefully reduced — at the expense of reduced amplifier bandwidth — by wiring external resistors in series with the source terminals of the two MOSFETs of the CMOS stage, as shown in the 'micropower' circuit of Figure 25. This diagram also shows the effect that different resistor values have on the drain current, voltage gain, and bandwidth of the amplifier when it is operated from a 15 volt



■ FIGURE 21: 4007UB TRANSMISSION GATE OR BILATERAL SWITCH.

■ FIGURE 22: 4007UB TWO-WAY TRANSMISSION GATE.



supply and has its output feeding to a 10M/15pF oscilloscope probe.

It is important to appreciate in the Figure 25 circuit that these additional resistors add to the output impedance of the amplifier (the output impedance roughly equals the R1-Av product), and this impedance and the external load resistance/capacitance has a great effect on the overall gain and bandwidth of the circuit. When using 10K values for R1, for example, if the load capacitance is increased to 50pF the bandwidth falls to about 4kHz, but if the capacitance is reduced to 5pF the bandwidth rises to 45kHz. Similarly, if the resistive load is reduced from 10M to 10K, the voltage gain falls to unity. Thus, for significant gain, the load resistance must be large relative to the output impedance of the amplifier.

The basic (unbiased) CMOS inverter stage has an input capacitance of about 5pF and an input resistance of near-infinity. Thus, if the output of the Figure 25 circuit is fed directly to such a load, it will show a voltage gain of about x30 and a bandwidth of 3kHz when R1 has a value of 1.0M; it will even give useful gain and bandwidth when R1 has a value of 10M, but will consume a quiescent current of only 0.4µA! The CMOS linear amplifier can be used, in either its standard or micropower forms, to make a variety of fixed-gain amplifiers, mixers, integrators, active filters and oscillators, etc. Three typical basic applications are shown in Figure 26.One attractive 4007UB linear application is as a crystal oscillator, as shown in Figure 27(a). Here, the CMOS amplifier is linearly biased via R1 and provides 180° phase shift, and the Rx-C1-XTAL-C2 pi-type crystal network gives an additional 180° of phase shift at the crystal resonant frequency, thereby causing the circuit to oscillate. If this circuit is needed to provide a frequency accuracy within only 0.1% or so, Rx can be replaced by a short and C1-C2 can be omitted; for ultra-high accuracy, the correct values of Rx-C1-C2 must be individually determined (Figure 27 shows the typical range of values). In micropower applications, Rx can be incorporated in the CMOS amplifier, as shown in Figure 27(b). If desired, the output of the crystal oscillator can be fed directly to the input of an additional CMOS inverter stage, for improved waveform shape/amplitude.

PRACTICAL CIRCUITS — ASTABLES

One of the most useful applications of the 4007UB is as a ring-of-three astable multivibrator; Figure 28 shows the basic configuration of the circuit. Waveform timing is controlled by the values of R1 and C1, and the output waveform (A) is approximately symmetrical. Note that for most of the

waveform period the front-end (waveform B) part of the circuit operates in the linear mode, so the circuit consumes a significant running current.

In practice, the running current of the Figure 28 astable circuit is higher than that of an identically configured B-series 'buffered' CMOS IC such as the 4001B, the comparative figures being 280µA at 6V or 1.6 mA at 10V for the 4007UB, against 12µA at 6V or 75µA at 10V for the 4001B. The 4007UB circuit, however, has far lower propagation delays than the 4001B and typically has a maximum astable operating speed that is three times higher than that of the 4001B.

The running current of the 4007UB astable can be greatly reduced by operating its first two stages in the 'micropower' mode, as shown in Figure 29. This technique is of special value in low-frequency operation, and the Figure 29 circuit, in fact, consumes a mere 1.5µA at 6V or 8µA at 10V, these figures being far lower than those obtainable from any other IC in the CMOS range. The frequency stability of the Figure 29 circuit is not, however, very good, the period varying from 200 mS at 6V to 80 mS at 10V.

Figure 30 shows the 4007UB wired as an asymmetrical ring-of-three astables in which the circuit's 'input' is applied to n-channel MOSFET Q2; this circuit consumes a mere 2µA at 6V or 5µA at 10V. Figure 31 shows how the symmetry of the circuit can be varied by shunting R1 with the D1-R3 network, so that the charge and discharge times of C1 are independently controlled; with the component values shown, this circuit produces a 300µS pulse once every 900 mS and consumes 2µA at 6V or 4.5µA at 10V.

Finally, to complete this look at the 4007UB IC, Figure 32 shows how

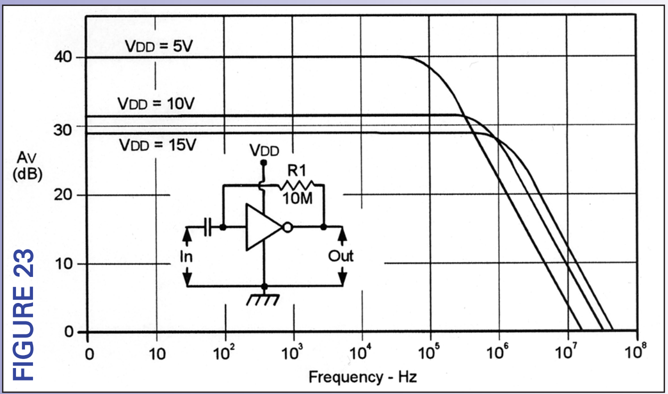


FIGURE 23

■ FIGURE 23: TYPICAL AV AND FREQUENCY CHARACTERISTICS OF THE LINEAR-MODE BASIC CMOS AMPLIFIER.

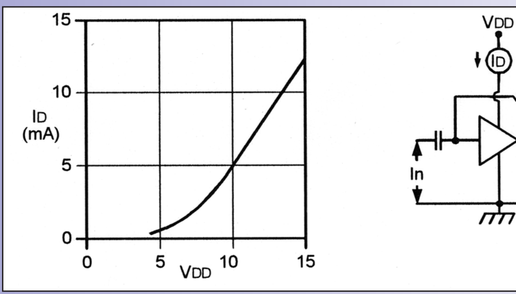
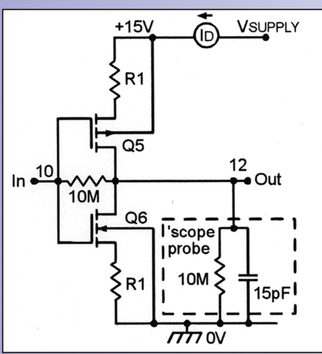


FIGURE 24

■ FIGURE 24: TYPICAL ID/VDD CHARACTERISTICS OF THE LINEAR-MODE CMOS AMPLIFIER.



R1	ID	AV (Vout/Vin)	Upper 3dB Bandwidth
0	12.5mA	20	2.7MHz
100R	8.2mA	20	1.5MHz
560R	3.9mA	25	300kHz
1k0	2.5mA	30	150kHz
5k6	600µA	40	25kHz
10k	370µA	40	15kHz
100k	40µA	30	2kHz
1M0	4µA	10	1kHz

FIGURE 25

■ FIGURE 25: 'MICROPOWER' 4007UB CMOS LINEAR AMPLIFIER, SHOWING METHOD OF REDUCING ID, WITH MEASURED PERFORMANCE DETAILS.

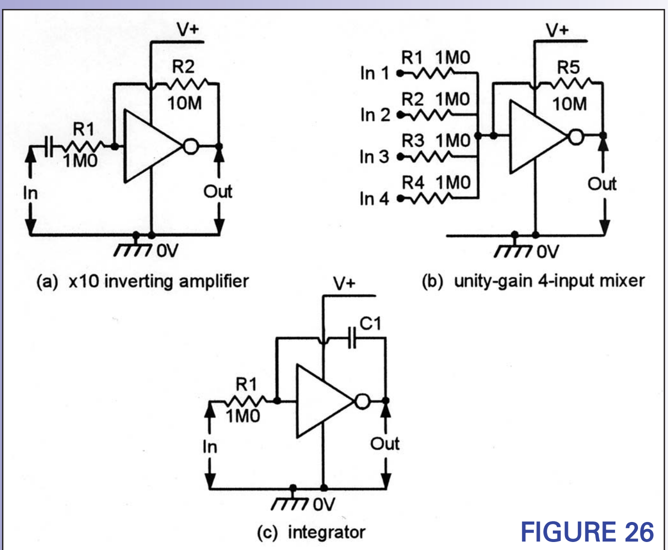


FIGURE 26

■ FIGURE 26: THE CMOS AMPLIFIER CAN BE USED IN A VARIETY OF LINEAR INVERTING AMPLIFIER APPLICATIONS. THREE TYPICAL EXAMPLES ARE SHOWN HERE.

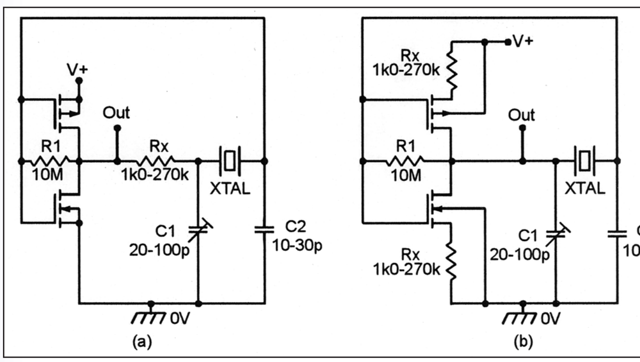


FIGURE 27

■ FIGURE 27: CRYSTAL OSCILLATOR USING (A) STANDARD AND (B) MICROPOWER 4007UB CMOS LINEAR INVERTER.

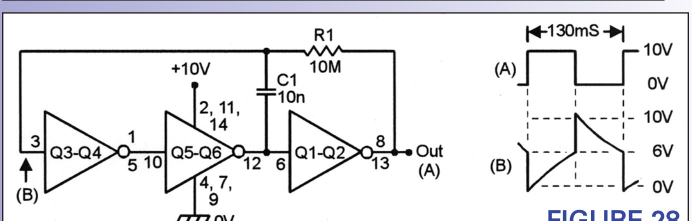
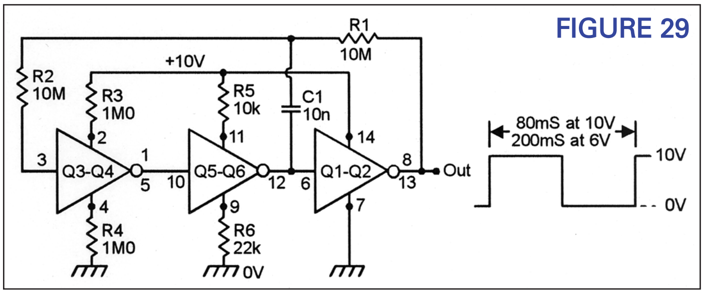
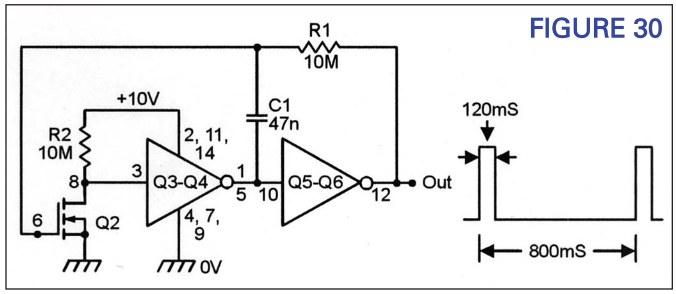


FIGURE 28

■ FIGURE 28: THIS 4007UB RING-OF-THREE ASTABLE CONSUMES 280µA AT 6V, 1.6 MA AT 10V.



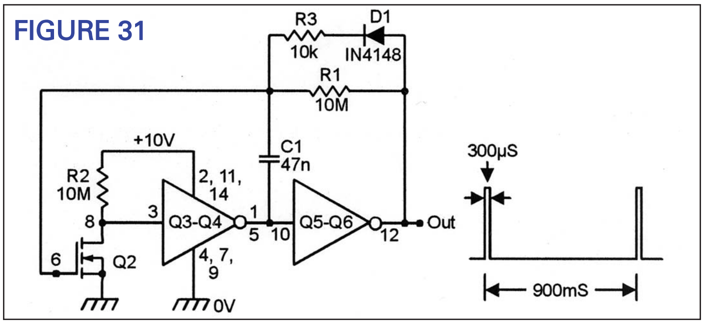


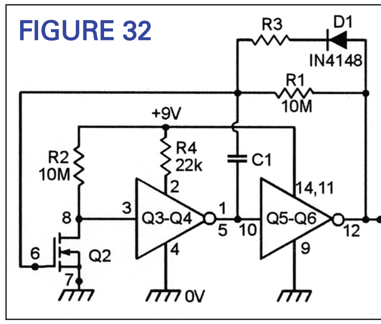
■ FIGURE 29. THIS MICROPOWER RING-OF-THREE SYMMETRICAL 4007UB ASTABLE CONSUMES 1.5µA AT 6V, 8µA AT 10V.

■ FIGURE 30. THIS 4007UB ASYMMETRICAL RING-OF-3 ASTABLE CONSUMES 2µA AT 6V, 5µA AT 10V.

■ FIGURE 31. THIS DUAL-TIME-CONSTANT VERSION OF THE 4007UB ASTABLE GENERATES A VERY NARROW OUTPUT PULSE.

■ FIGURE 32. THIS MICROPOWER VERSION OF THE 4007UB DUAL-TIME-CONSTANT ASTABLE CONSUMES ABSOLUTELY MINIMAL CURRENTS.





C1/R3 value	Imean at 9V	W	P
47n/10k	1.5µA	300µS	900mS
10n/33k	3.5µA	160µS	180mS

the Figure 31 circuit's current consumption can be further reduced by operating the Q3–Q4 CMOS inverter in the micropower mode. The table gives details of circuit performance with alternative C1 and R3 values. This circuit can give years of continuous operation from a small nine-volt battery. ■

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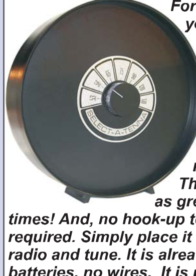

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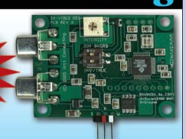

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READER FEEDBACK

Continued from page 28

COMIN' DOWN

Babylonians tried that (Space Elevator) in 3000BC and wound up babbling and confused. What is going to hold that thing up when somebody starts his climb? Now, I know people are suggesting that light rays or ion beams can be harnessed to force things up the space elevator track, but I am not going to bet on success of any of it. I have operated inductive force gadgets but that is more kick than I can tolerate and lasers burn their targets. I think people should get real for a change.

Robert C. Gibson

NATURE LOVER

I recently found the November 2005 issue of *NV* sitting on a table at a local SUBWAY restaurant. As an Extra Class Amateur radio operator, I thought it might be interesting.

I must say it is a very informative publication; and, as a student of human nature, I found Gerard Fonte's thesis "Human Nature" particularly enlightening and, while tongue-in-cheek, quite truthful, as well. Please forward my congratulations to him for a very well-written article.

David Deschesne
Presque Isle, ME

LOSS OF GRIP

The October 2005 issue of *NV* has articles with problems. "Whimsical Doorbell": Figure 4 titles "Transmitter Schematic" is a duplicate of Figure 5 "Receiver Schematic." "I Love my Heils!": This article is poorly written. The sheet of paper example did not make much sense to me. The "Conclusion" paragraph is a wonder. And the author fails to point out, if this AMT technology is so great, why has it not been more successful. "Data Processing Using SCAM": This article series does not seem appropriate for a hobbyist magazine. Too esoteric, more suited to an electronic engineering journal.I am not usually so critical, but you lost your grip with the October issue.

Ernie Worley

ZILOG & LOVIN' IT

I just wanted to thank you for adding the Zilog part to your magazine. I hope that you keep the Zilog parts from now on. I started using the Z-80 many years ago, and it's always been a pleasure to work with. I'm just now starting to learn to use the PIC processors, and the more I learn about it and use, the less I like it.

Besides, it's always nice to see more out there, instead of going all PIC, all the time. If everybody is offering articles on the PIC, then you're not giving me anything everybody else isn't (I think?? You get the idea). If they're offering the PIC, and you're offering something else, then you're different! Bonus! Everybody seems to "do the PIC," so it's nice to see something different for a change. But don't leave the PIC out altogether. It's still nice to work with once in a while. But it's nice to see other parts out there, as well. And who knows, if Zilog starts getting more and more hobbyists using their parts, maybe, just maybe they'll get on the support ball and start supporting us end users!!

Jack Steinhilper

■ BY GERARD FONTE

HUMAN NATURE — Part 2

This month, we'll take a somewhat more serious look at human behavior than last month and examine what motivates people and how to understand why people act as they do. We'll see that once you learn the underlying principles of behavior, some seemingly absurd actions can actually be normal and expected.

Being able to interact well with other people is clearly useful and important for any engineer. And, typically, this is difficult for many engineers to do well. Note that this is actually a companion article to last month's column. You may find it amusing to do a side-by-side comparison.

MOTIVATION

There is one single concept that, when properly understood and applied, will allow anyone to understand anyone else's behavior. This is the concept of "motivation." This is the thing that controls behavior. Everybody has a reason for doing what they do (or don't do — like clean the garage). Of course, different people have different reasons. And if the person is too different from you, the reason isn't apparent and the behavior appears to be completely irrational. Engineers as a group are generally different from the average person. This means that engineers will have difficulty understanding the behavior of non-engineers and vice versa. There are lots of examples and I'll let you think of one that you've experienced.

The key fact about motivation is that all people have the same motivations. It is only the strength of these motivations that is different. Everyone wants to be rich, famous, healthy, and smart. But some would rather be smart than rich, and so forth. Of course, there are negative motivations, as well. No one wants to be in jail, be laughed at, or hated by their family. (However, sometimes motivations clash. For example, you might prefer to spend a night in jail instead of freezing on the street.)

You choose the direction of your life based on what you feel is important to you. Your personality is shaped by these motivations just as your motivations shape your personality. It's not too far from the truth to say that a person is defined by their motivations. This is why engineers — as a group — share similar personality traits. They value similar motivations. (Note, for the rest of the column when I refer to a person's "motivations" I am really discussing the strength or priority of those motivations. It's simpler and less wordy.)

What this means is that if you can imagine yourself acting under different motivations, you can understand a different person's behavior. And once you understand their behavior, you will have a better insight of how that person operates. Like a machine, once you know how it operates you can anticipate the behavior. This insight can give you influence over how that person behaves. Again, like a machine, you will know what buttons to push to get a proper response. (Well, at least a better chance of getting a proper response.) People are not machines. They're obviously much more complicated. Worse, a person's motivations can change. Sometimes, especially after a very emotional event, their motivations can be completely reorganized. People are intricate and unpredictable.

PRESS ANY KEY WHEN READY

I was in a meeting with about 10 vice-presidents, program directors, and executives when someone brought up the point that the software required the operator to "Strike any key when ready." The ensuing discussion lasted about an hour. Everyone had something to say. Often the discussion appeared ludicrous. But no one (except me, apparently) seemed to really notice what was going on. Here were 10 senior people wasting time and money (big-salary money) arguing over an insignificant aspect of the project. Why were they doing that? And why didn't anyone recognize how silly some of the suggestions were?

The simple reason is that these people wanted to contribute to the project. They managed and oversaw the project but never actually touched it. Now, they had an opportunity to put their mark on it. This is a strong motivation. After all, wouldn't you like to say that you contributed to the Mars rover or Apple computer or a cure for cancer? Being a part of something larger is a fundamental human motivation. That's why we are social animals. A key point is that there was no technical education or training necessary to contribute to this discussion. It wasn't a choice between polled software versus interrupts, where someone had to fully understand the concepts and implications in order to add something meaningful. "Strike any key when ready" was a topic that everyone could understand and talk about. Each person had an opinion and wanted to express it (another motivation).

But why was everyone oblivious to the content of some of the suggestions? This is really very simple. They weren't listening. When someone has something important to say, they become impatient and search for an opportunity to say it. When you are just waiting for someone to stop speaking so you can start, you aren't really hearing what they are

expressing. So after an hour of comments, suggestions, and opinions, "Strike any key when ready" was changed to "Press enter when ready." It was a silly waste of time and money. But hopefully, you can now see that there were rational reasons for that behavior. And, in the future, don't present anything non-technical to a group of executives (unless you don't want time to discuss the real issues).

GROUP INTELLIGENCE

In theory (and on TV), a group of people have the ability to pool their knowledge so that the intelligence of the group is the sum of the individuals. This means that the group should be much more intelligent than any of the individuals within the group. Unfortunately, this is not always the case.

I was once involved in a "Team Building" exercise with about eight others (non-engineers). The scenario was that we had just survived a plane crash in the desert and had to rank the survival importance of 10 items recovered from the wreckage. The interesting thing was that we each ranked the items first, in isolation. Then we got together and decided, as a group, how best to rank the same items. The results were illuminating. If you took the average of the individual scores, the result was about 60% (out of 100%). Obviously, this wasn't very good. However, as a group, the score was about 75%. Much better.

The instructor emphasized how this showed how great teamwork was. This clearly displayed the value of teamwork because the group intelligence had increased. Unfortunately, this is not entirely the case. The problem with his statement was that it ignored the fact that several individuals scored 85% to 90% on their individual ranking. What we really see is that the high-scoring individuals increase the group intelligence more than the low-scoring people reduce it. And my own experience and informal observations confirm this. Group intelligence helps the weak and hinders the strong. Why? Let's examine one "recovered" item — salt tablets. My view was that these were dangerous and should be discarded and be ranked last. I knew salt water was not potable. So, I figured that ingesting pure salt in the desert should be just as bad as drinking salt water (which it is). However, another person disagreed. His high-school coach gave him salt tablets after working out and he believed that they were necessary. He was unwavering in his belief and logical arguments could not change that. After a while, I gave up the discussion and generously told him he could have my salt tablets.

The important point is to see the motivations of the participants. Everyone wanted to survive. Everyone wanted to contribute to the survival of the group. I had been talking a lot and realized that the group was getting tired of listening to me. I also realized that I might have other important points to make later on. So, my motivation to stop was peer pressure and logic. The group wanted me to stop because I was talking too much and trying to make too many changes. They were socially motivated to reign in anyone that was perceived to be too different from "the group." More simply, nobody likes a know-it-all. (I suspect that this situation is familiar to many readers.)

Lastly, the ex-athlete was motivated to contribute. He was unwilling to listen to logic because he was never trained or educated that way. Additionally, his personal motivations elevated faith and trust over reason and analysis. When I realized this, I knew that further discussions were futile. There was no common ground.

POINT OF VIEW

All of these examples explain different points of view. We can also see that a person's point of view depends upon his motivations. Being able to see another point of view is also being able to imagine yourself with different motivations. This is the key ability needed to understand someone else. This is something that is not easy to do. You have to step outside yourself and ask "what would it be like to value peace-of-mind over logical reasoning," as with the ex-athlete. If you can do that, you will realize that there is great serenity and stability with that way of thinking. Serenity and stability are important motivations. But this is difficult because engineers value a world that is growing and changing.

There is an inherent conflict of motivations between these two types of personalities. However, once you are aware of the method you can practice it. Being able to change your point of view to understand someone's behavior is a skill that takes effort and practice. But, all you have to do is ask yourself, "What motivated that person to behave that way?" and "How would I feel/act if I had those motivations?" After a while, you can learn to understand and predict other people's behavior. Not coincidentally, this technique can be used to improve your acting skills, as well.

MALE AND FEMALE BEHAVIOR

A lot has been said and written about the differences between male and female behavior. There are those that feel that it is inborn and others that think it's learned. For this discussion, it really doesn't matter except to note that there are indeed differences. However, we again see that different male/female motivations are the reason for this.

A while back, I read about an interesting psychological experiment that compared males and females and their ability to name and discriminate colors. The discrimination part was easy. They presented two similar colors and asked the subjects if they were the same or different. This allowed them to measure how close two colors had to be before they were perceived as the same color. The interesting thing was that males and females scored the same. There was absolutely no difference between the sexes in the ability to distinguish colors. In the second part, they asked the subjects to name the color. Here, there was a huge difference. A man would say the color was "purple." A woman would say that same color was "periwinkle with a touch of lavender." Not only that, different women would describe the color in the same way. The clear explanation was that females had a much larger vocabulary for colors than males. Where men might have 10 to 20 colors they could identify by name,

females had hundreds. Since there was no difference in the ability to discriminate between colors, it becomes clear that there was a motivation for females to identify colors that wasn't present in men. Why?

Simply, women are more colorful and fashionable than men. (I won't discuss why this is the case. But just look around at work or at the mall.) Men's fashions haven't really changed for a hundred years or so. A suit and tie is still a suit and tie. There may be minor changes in the cut or fabric, but a 20 year old suit can still be worn (and often is). On the other hand, a women's wardrobe changes yearly. Last year's fashions and colors are often just not suitable for this year.

This fashion/personal-appearance motivation forces women to be able to describe many colors and styles. Additionally, we can see other behaviors that emerge from this once we use that point of view. The importance of appearance of themselves gets transferred to other things that are important to them, as well. They wrap their gifts with special care to look especially nice. They are concerned that their husband or boyfriend dresses and appears well. "You're not going to wear that, are you?" is something a man will never say to a women (unless the clothes are too revealing — which is another motivation altogether). But women say this with regularity. And it makes sense, once you understand their motivation and apply their point of view. Of course, the opposite applies to men. "Why do I have to change my clothes? I'm just going to the store." This is why women think, "All men are pigs."

CURIOSITY AND SOCIAL PRESSURE

Curiosity is one of the most powerful and basic human motivators. There is absolutely no doubt that man's curiosity is far greater than any other creature on Earth. It's the foundation of science and technology. Engineers and scientists are motivated by this more than the average person. We enjoy asking questions, solving puzzles, and figuring out problems. We like making things to see if they will work as well as we imagine. All of this demands a high level of curiosity. This means that it is very difficult for us to understand other people's lack of curiosity and consequently, their behavior.

This creates a conflict between engineers and non-engineers. Engineers want to do new things, create new machines, and explore new ideas. Society values the status quo. "Why do we need to go to the Moon when we have problems here on Earth?" This motivational conflict is perpetual because people don't like changing. (Would you like to randomly go to bed between 9 PM and 2 AM every night?) The good news is that the status quo can change quickly if the individuals decide to. This is often seen with technological innovations. Initially there is a great resistance to the idea, but once proven, it is rapidly accepted. "Fulton's Folly" (the steamboat) is a typical example.

Nevertheless, this social unease does not make an engineer's life easier. Like the previous "group intelligence" example, there are often situations where an engineer or scientist must weigh social acceptance against his curiosity. When you go to a friend's holiday party, is anyone (except you) excited about your new technique for 3-D imaging? Or do they stare blankly and nod their head at the wrong times? Yet, everyone listens in rapture to a photographer talking about his photo session with Wilford Brimley. Eventually, the engineer realizes that his excitement about his interests is not shared by the listener and stops talking. What we see is that the social pressure/conflict of motivations forces the engineer to be socially withdrawn. It's not so much that engineers have a difficult time with people, as that people have a difficult time with engineers. And in order to fit in with the group, the engineers have to change their behavior.

PURSUIT OF HAPPINESS

Some motivations are subtle.

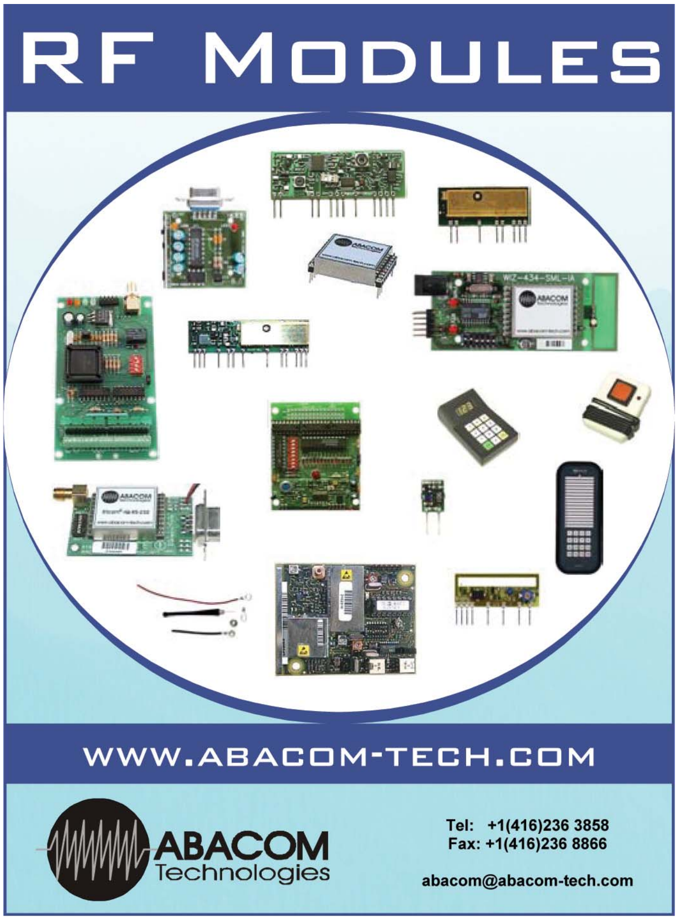
Some enhance personal growth. Some cause society to change. The pursuit of happiness is one of these. What does it take for you to be happy? The free-market "work-ethic" is subtle and pervasive throughout all the industrialized world. It's a motivation you may not even be aware of. The idea is that if you work hard you will get money to buy things that you feel you will need to be happy. This is not a human motivation. It's a social motivation.

The clearest examples of this are the Polynesian societies before they were discovered by western explorers. These tropical societies had no work-ethic at all. Food was plentiful. There were all sorts of wild fruits and edible plants free for the picking. There were plenty of fish in the sea that were easy to catch. The jungle provided materials for huts and simple tools. Their societies were what we could only classify as idyllic. They spent very little time taking care of the necessities of life. The remainder of their time they spent amusing themselves. They played games, swam in the ocean, spent time on artistic endeavors. They did all those things you can imagine doing in such a delightful environment. These people were completely content with their society. It was a static society. There was no industrialization and no motivation to "improve themselves." It all changed when they were overrun by explorers, missionaries, and traders.

Consider this. Suppose you get a four percent raise. You use that money to buy more things ... a new car, a plasma TV, or redecorate the house. It is implicitly assumed that a raise means more money. But suppose you were able to work four percent less, instead of getting four percent more money. This would be the equivalent to an additional two weeks of vacation. Would you choose the extra vacation or the additional money? It's been found that the vast majority of people in industrialized nations will take the extra money. The social work-ethic/self-improvement motivation is something that we are exposed to from every facet of society. We are taught this. Perhaps as humans, we are susceptible to this. But it is still a social motivation, not a human one. There are other social motivations, as well. I think it's important to realize this.

CONCLUSION

Human behavior is based on motivations. All humans have the same inherent motivations but assign different values to them. This results in different behaviors. However, if you can determine what their motivations are and can see their point of view, you will be able to understand, predict, and affect how others behave. Some motivations are based on human nature while others are developed from society. And it is noteworthy that virtually all humor is based on some peculiar behavior of a person, animal, or thing. So, understanding motivation also allows you to understand humor. ■


RF MODULES
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Fax: +1(416)236 8866
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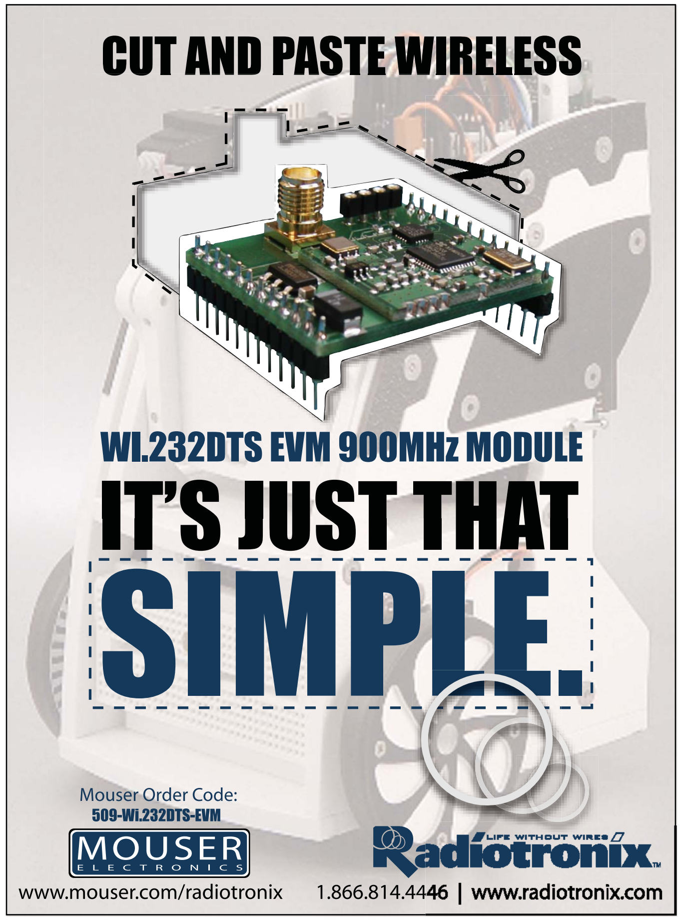
CUT AND PASTE WIRELESS
WI.232DTS EVM 900MHz MODULE
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■ BY LOUIS E. FRENZEL

INTERNET TELEPHONES

End-to-End Digital Telephony

BY NOW, YOU HAVE ALL PROBABLY heard of Internet telephones, or IP phones as they are sometimes called. They are also known as voice over Internet protocol or VoIP phones. In fact, you may already have one if you are one of those early adopters of high tech stuff. If you don't have one, you can almost be sure that a VoIP phone is in your future. Let's take a look at how these phones work.

PLAIN OLD TELEPHONE SERVICE (POTS)

POTS is the name of the original telephone system. In case you don't know it, this is by far the largest communications network in the world. You can actually call anyone else in the world using this system which is considered yesteryear's technology. The POTS system is a hybrid meaning part analog and part digital. From your phone to the telephone central office is a long twisted pair cable (up to 18,000 feet long but usually less) called the local loop. It carries your voice and that of your caller in analog voice format. Simple. Your phone is probably analog but it can be partially digital if you have one of the newer digital cordless phones. Your voice signal is just an audio waveform on the twisted pair to the central office.

After your voice gets to the central office, it is immediately converted to digital and transmitted in serial digital format to another central office for a local call or by way of intermediate call centers for long distance. It may be transmitted over coax cable, twisted pair, microwave link, or fiber optic cable. Or usually some combination. And for certain long distance calls, your digitized voice may pass through a satellite. If your call is to a cell phone, then the connection is over one or more wireless links. In case you never thought of it, a phone call is a pretty complex event we take for granted. The whole thing is pretty impressive when you think of it because that system is our second oldest electronic communications system (telegraph was first) that came into being in 1876.

The complex part of a phone call is creating the link from one phone to the other. It is done with electronic switching and those switches are set by the Touch Tone numbers you press. We still call it dialing although dial phones went out decades ago. The electronic switches in the central office and long distance service centers connect you directly to the called phone establishing a fixed link for the duration of the call. Then you talk. When you hang up, the link disappears.

Overall, our telephone system is pretty cool. It is extremely reliable and even more reliable than electrical power which fails far more often in storms. And while it is older technology, the POTS system works great and still gets the job done. Most subscribers are not complaining. However, we are on the verge of changing all of that and replacing this very effective "institution" with something more contemporary and very complex. It is known as Voice over Internet Protocol (VoIP).

VOIP

VoIP is the process of using the Internet to make phone calls. We by-pass the entrenched telephone system completely. We do this by using an Internet Protocol (IP) phone that digitizes our voice then transmits it in packet format over a broadband Internet connection such as that on a cable TV system or a DSL phone line. The packetized voice travels through multiple routers and servers on the Internet until it gets to where it is going. Then the digitized voice is converted back to analog so we can hear it. The whole process makes use of the available Internet system without the need to rewire the world again. And it works world wide. The question you have to ask is, "why are we doing this?" One answer is, just because we can.

Really, the primary reason people are switching to VoIP is that it may be somewhat less expensive than

maintaining a separate phone line with long distance service. This, of course, assumes you also have a high speed Internet connection called broadband service such as cable TV service or a DSL line. A standard dial up modem just will not handle VoIP. According to a recent survey, about 42% of the US population has a broadband connection. Once you have your high speed broadband connection, the telephone service is only a small extra cost item and there is no extra charge for long distance. Paying your monthly broadband cable or DSL bill and adding the VoIP service produces a total that is typically less than your broadband bill plus phone and long distance. What you really need to do is check this out for yourself given the local services available to you. VoIP may not be less. For example, if you have a DSL line it means that you also have a regular POTS telephone line that is used for the Digital Subscriber Line service. And you must have that first to add VoIP service which adds to the bill. In some cases, you may be trading dollars. You need to see for yourself.

Otherwise, VoIP service does pretty much the same thing as a regular telephone line. There are a few things that are different. First, if you have a power failure, you have no phone service because your IP phone is electronic and needs AC power. But that is no different if you currently have an electronic/cordless phone with POTS. The regular older analog phone gets its power directly from the phone line which supplies 48 volts DC to power all the circuits. Second, there is no directory service where you can get a phone number from an operator. And third, in some areas there is still no 911 service. IP phone carriers must tell you if 911 calling is not available. All of them are supposed to have it eventually. Each locality is different.

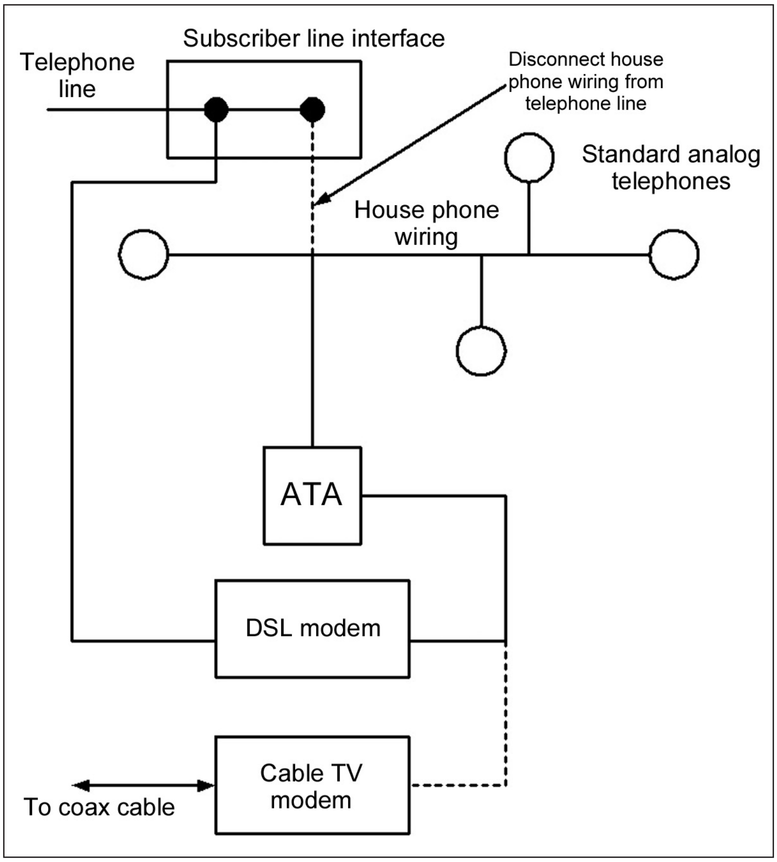
Where the big savings comes is telephone service in big companies. When many phones are involved and all must have long distance service, telephone expenses are huge. VoIP can really reduce the cost of phone service in such cases. Company IP phones just connect to the company's already installed Ethernet LAN (local area network) then on to a server and router connected to the Internet. The switch-over to VoIP began in the big companies and other organizations a few years ago, but is now slowly catching on with consumers as broadband high speed Internet services become available to most homes.

HOW IT WORKS

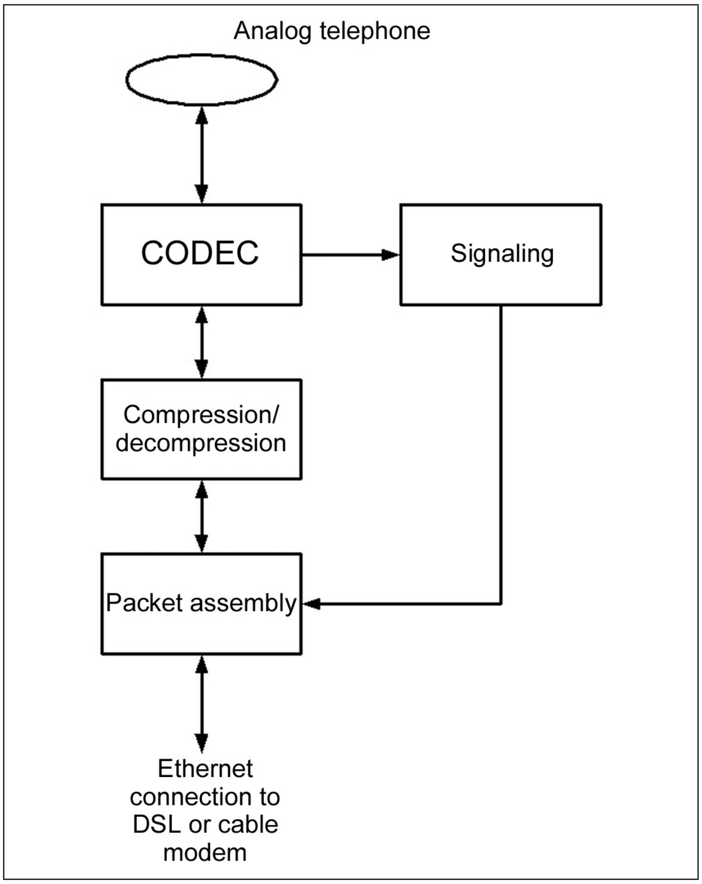
Most home-based VoIP services let you use your existing POTS telephone. It simply plugs into a device called an Analog Terminal Adapter (ATA). The ATA is furnished by your cable TV or DSL company. Regardless, the ATA digitizes your voice and does the other digital dialing operations needed to use the Internet. The ATA then connects to your cable TV or DSL modem by way of a short CAT5 Ethernet cable. In some cases, the cable or DSL modem is packaged together with the ATA and the resulting combination is referred to as a voice gateway or broadband gateway.

Figure 1 shows the basic connections. What you do is disconnect your standard telephone line from your internal house phone wiring. This is easily done at the subscriber line modular interface where the line comes into your home. Then you connect the house phone wiring to the ATA with regular phone cables with RJ11 modular plugs. The ATA connects to the modem. If you have a DSL line, the DSL modem or gateway must then connect to your regular phone line, but at its point-of-origin in the subscriber line interface. You cannot use the internal house wiring to connect a DSL modem to the telephone line if you are using it to connect your phones to the ATA.

Figure 2 shows the processes involved in making an IP call. You first dial the number as you normally do. Inside the phone, a CODEC converts the voice and Touch Tones into digital signals. The codec is short for coder-decoder and is a combined analog-to-digital converter (ADC) and a digital-to-analog converter (DAC). An embedded microcontroller running signaling software converts the digital Touch Tone signals into a packet containing the Internet address that refers to the



■ **FIGURE 1.** CONNECTING YOUR STANDARD ANALOG HOME PHONE TO A VoIP SYSTEM. WHILE BOTH CABLE AND DSL MODEMS ARE SHOWN, ONLY ONE WILLBE USED. IT MAY BE PACKAGED WTH THE ATA IN A SINGLE BOX.



■ **FIGURE 2.** THE PROCESS OF CONVERTING VOICE AND TOUCH TONES INTO VOIP PACKETS. THE CODEC IS MADE UP OF ANALOG-TO-DIGITAL AND DIGITAL-TO-ANALOG CONVERTERS. THE SIGNALING AND PACKET ASSEMBLY IS USUALLY HANDLED BY AN EMBEDDED PROCESSOR. THE COMPRESSION AND DECOMPRESSION IS PERFORMED ON A DSP. SOME ADVANCED INTEGRATED CIRCUITS PACKAGE ALL OF THESE FUNCTIONS ON A SINGLE CHIP.

phone number. The process of creating this packet and sending it is based on one of two commonly used signaling protocols. One is the International Telephone Union (ITU) standard H.323. The other is the Internet Engineering Task Force (IETF) session initiation protocol (SIP). H.323 is older but SIP has now become the de facto signaling standard in most IP phones. The packet travels through any number of servers and routers until it reaches the phone you want to call. The connection is established for that packet.

When you talk, your voice is digitized by the ADC in the CODEC. The ADC samples your voice 8,000 times a second (8 kHz rate) and generates an eight-bit word for each sample. These are put into serial format one after another creating a 64K bit per second (64 kbps) data stream. This is referred to as pulse code modulation (PCM). The ITU gives this signal the standard designation of G.711.

To eliminate the need to transmit that much data that fast, the PCM signal is compressed usually by an embedded controller like a digital signal processor (DSP). Compression is the process of reducing the total number of bits transmitted and their data rate without ruining the intelligibility of the voice signal. Such compression is possible because there is so much silence in any conversation. Pauses, time between words and sentences, etc., are not digitized so the voice signal uses fewer bits transmitted faster. A variety of compression standards are used. G.729a produces an 8 kHz signal. G.723 produces a lower quality compressed signal of only 5.3 kHz.

The compressed data is then packaged into a packet for transmission (see Figure 3). The packet is defined by the H.323 standard and uses 128 bytes (1,024 bits) and includes a header that aids in synchronization at the receiver, source and destination addresses, and a forward error correction (FEC) word to help in bit error detection and correction. The Internet Protocol (IP), Real Time Protocol (RTP), and User Datagram Protocol (UDP) headers are involved in the intermediate processing of the packet along the transmission path.

Each packet contains 56 bytes of compressed byte data. The packet gets transmitted via the cable or DSL modem to the Internet Service Provider (ISP). The packet is then translated into a standard TCP/IP protocol packet. The router at the ISP sends the packet on through the Internet where it eventually passes through multiple routers before it gets to its destination.

Since most conversations are longer than 56 bytes, the additional voice data is packetized as described and the packets sent out one after the other. When passing through the Internet, the packets may actually get out of sequence since they all may not travel the same path. Packets pass through different routers as the Internet traffic changes over time. At the receiving phone, the packets are put back into sequence, decompressed, and sent to a DAC converter to recreate the voice signal.

The only reason this system works is that the data is transmitted very fast over the Internet. In most cases, the packets blast along at 2.5 Gbps over the fiber optic cables making up the Internet. But it could

■ **FIGURE 3.** THE VOIP PACKET IS MADE UP OF 128 BYTES AND INCLUDES ETHERNET, IP, RTP, AND UDP HEADERS FOR INTERMEDIATE PROCESSING. ONLY 56 BYTES OF VOICE DATA IS TRANSMITTED. AS MANY PACKETS AS NEEDED ARE CREATED TO SEND THE ENTIRE VOICE CONVERSATION.

Ethernet header 26 bytes	IP header 20 bytes	UDP header 8 bytes	RTP header 12 bytes	Voice data 56 bytes	FEC and/or fill bytes 6 bytes

← 128 bytes →

be less or even as high as 10 Gbps. But the whole system adds latency or packet delays. It just takes time for a packet to pass through a router and get analyzed so the router can pass it along to the proper destination. These delays can sometimes be several hundred milliseconds (mS). As long as the latency is no more than about 150 mS from original transmission to reception, we usually can't tell or don't really notice. But if the latency is greater than that, we begin to notice since even a delay of a few seconds is maddening. The result is an annoying halting conversation because it takes time to send our voice and more time to hear the return. Most VoIP systems have been optimized to minimize this problem.

VoIP in a large company is implemented with special IP phones. The older standard phones like you have at home are not used. The IP phone produces the compressed voice signal mentioned earlier and puts it on a CAT5/6 Ethernet cable that connects to the company's LAN which is Ethernet. An employee typically will have an IP phone and a PC; the PC is also attached to the LAN. A two-way Ethernet switch allows the PC and the phone to share the same Ethernet connection.

VOIP OVER WIRELESS

VoIP is also fully compatible with wireless systems, as well. Once you get the voice into serial digital packets, it can travel over a wireless connection as easily as over a cable. For example, an IP phone can be connected to the company's LAN by way of a wireless Wi-Fi Ethernet access port, which is now very common in most companies. Your IP phone with a Wi-Fi or 802.11b/g radio is now cordless and you can carry it anywhere near an access point. You can also make phone calls from your IP phone from any public Wi-Fi hot spot. All you need is the 802.11 wireless LAN radio inside.

Some cell phone manufacturers (Motorola and Nokia) already put a VoIP Wi-Fi phone inside some of their regular cell phones. You can use the usual cell phone network or you can call via a Wi-Fi hot spot if one is available.

Another forthcoming reality is VoIP over WiMAX. WiMAX is the new wireless broadband system that will soon be showing up in some areas. It is an alternative to cable TV and DSL broadband lines and no cables are needed. The WiMAX provider will put up cell sites with high antennas that can reach VoIP phones over a radius of several miles. Its main purpose is high speed Internet access and digital TV, but you can make a call with such a phone any place you can access the WiMAX cell site. Typically, such phones will also have regular cell phone service and maybe even Wi-Fi connectivity. Then you never have to be out of touch. ■

■ BY PETER BEST

DIY EASY ETHERNET/FRAME THROWER

IF YOU WANT TO PUT YOUR FAVORITE MICROCONTROLLER ON A LAN, you're going to have to provide the microcontroller with an Ethernet interface. The same goes for that little microcontroller you want to talk to over the Internet. It's relatively easy to design the hardware part of the Ethernet interface, but it's a bit more complicated to put the logical IP architecture into code behind the Ethernet hardware design. The words, schematics, code, and pictures that follow in this installment of the Design Cycle will describe in total the realization of a fully functional PIC-based 10 Mbps Ethernet device based on Microchip's new ENC28J60 Stand-Alone Ethernet controller.

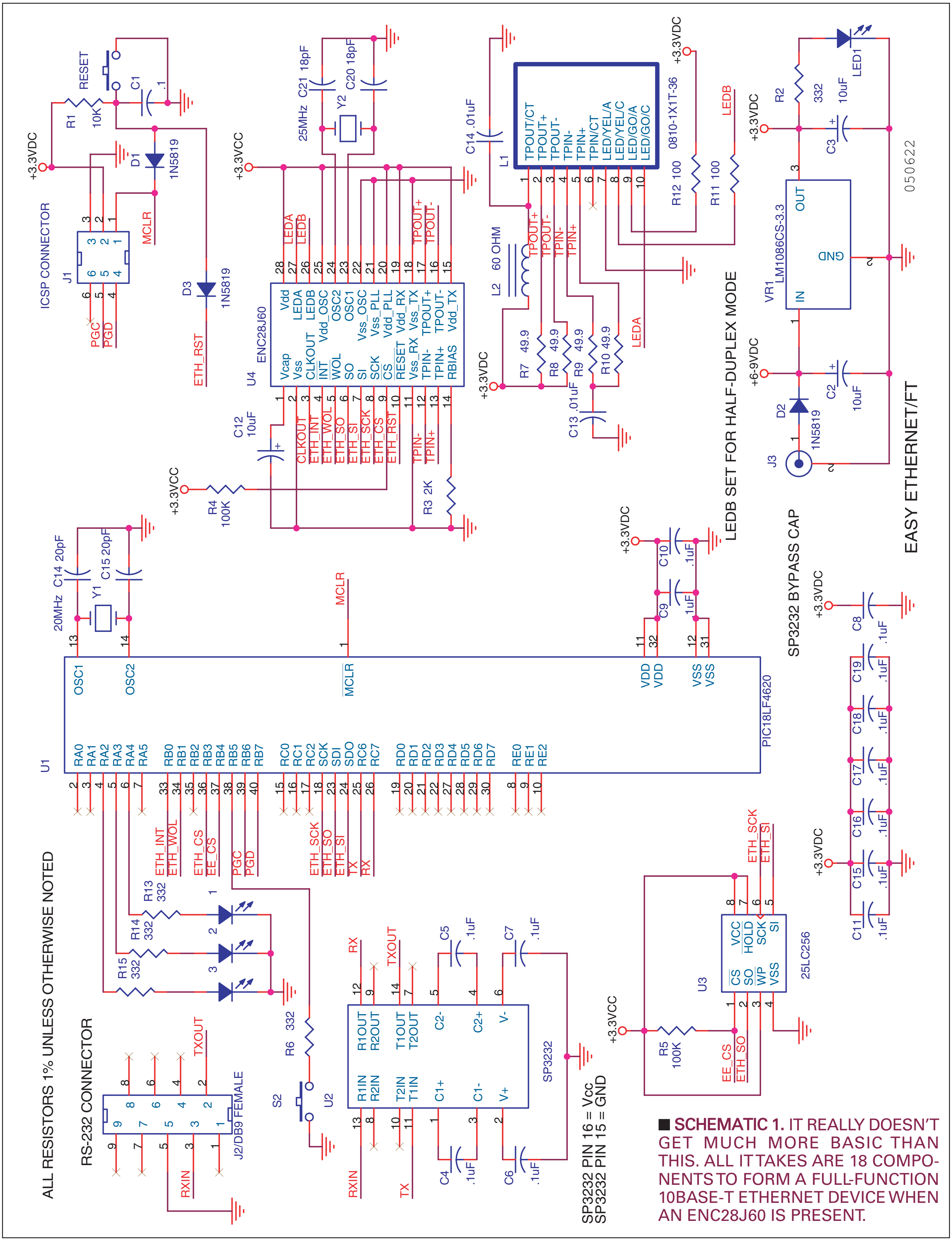
From what you've read in the preceding paragraph, you've probably already figured out that this is a "you can build this Ethernet project" article. For those of you that have made the transition to producing "from-scratch" projects with surface mount technology, the skill level needed to assemble your own ENC28J60-based module is minimal. The circuitry I'm about to describe can also be assembled as a standard "through-hole" project, as well. Just substitute the SMT components with their wired and socketable counterparts.

Designing and having "one-off" printed circuit boards made is the most expensive part of any home brew design. To offset that cost, I've arranged to provide professional printed circuit boards for this project for those of you that desire them. Another big expense is the accumulation of shipping charges associated with getting one part from here and another from there. Every part in the ENC28J60 Ethernet Controller project is an off-the-shelf part that can be had from many of the distributors that advertise in this magazine. For your convenience, I'll also make a comprehensive ENC28J60 Ethernet Controller SMT parts kit available for those of you that wish to get everything at the same time in one package.

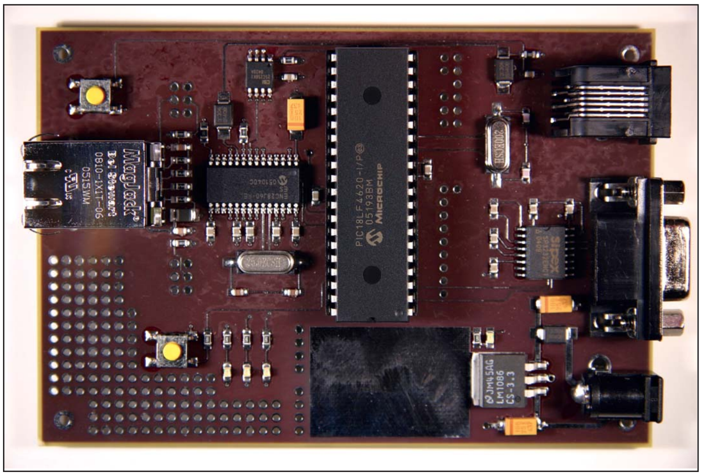
Remember the Digital Filter from a previous Design Cycle? Well, the Digital Filter electronic package is another easy and cost-effective way to get an ENC28J60-based Ethernet device online. In this article, I'll show you how to modify the original Digital Filter project to accommodate the ENC28J60 electronics.

If you're wondering whether or not you're going to need an extensive set of firmware development tools, don't worry. You won't need to write much code to get started. In fact, you won't need to write any home brew code to get started. The ENC28J60-based Ethernet design I'm about to present utilizes the services of the *free* Microchip TCP/IP Stack. In addition to MPLAB (which is also *free*), all you will need is the Microchip C18 C Compiler or the HI-TECH PICC-18 C compiler to recompile the Microchip TCP/IP Stack modules following a few minor changes we will apply to the stack's source code. A PIC programmer capable of programming PIC18FXXXX parts or a Microchip MPLAB ICD 2 will also be an essential item to have to complete this project.

Okay, the ENC28J60 Ethernet Controller project can be built with standard off-the-shelf components using both SMT or breadboard techniques, and the majority of the firmware to put the device on a LAN or the Internet is free for a download. All that's left to do before we begin is to name this thing. Since the ENC28J60 project basically throws Ethernet frames around on a network, I'll dub it Easy Ethernet/FT. The "FT" is short for Frame Thrower. In addition to standard Ethernet duties, the Easy Ethernet/FT design that you will be working with is based on the 40-pin PIC18LF4620 and includes a true RS-232 serial port, a Microchip ICSP programming/debugging port, a 32 KB SPI EEPROM, a user-definable pushbutton switch, three user-definable LEDs, and a regulated 3.3 VDC power supply. And, the Easy Ethernet/FT can be assembled from scratch or by modifying some existing PIC-based hardware you may already have on the bench (like that Digital Filter Dev Board). Before we begin, let's do a preflight on the ENC28J60.



■ **SCHEMATIC 1.** IT REALLY DOESN'T GET MUCH MORE BASIC THAN THIS. ALL IT TAKES ARE 18 COMPONENTS TO FORM A FULL-FUNCTION 10BASE-T ETHERNET DEVICE WHEN AN ENC28J60 IS PRESENT.



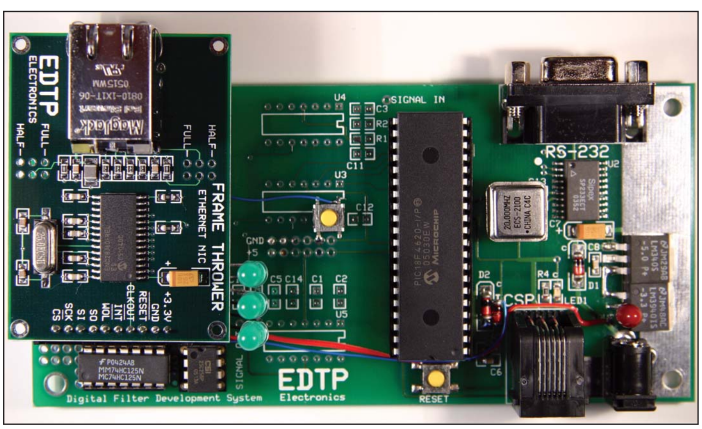
■ PHOTO 1. THIS IS A VIEW OF THE EASY ETHERNET/FT PROTOTYPE. ALL OF THE ENC28J60 CIRCUITRY IS LOCATED TO THE LEFT OF THE PIC18LF4620. EVERYTHING WE NEED IN A HARDWARE WAY TO TAKE ADVANTAGE OF THE FREE MICROCHIP TCP/IP STACK IS ON THIS BOARD.

THE ENC28J60

The ENC28J60 is available in a 28-pin DIP, SOIC, SSOP, or QFN package. A 10 Mbps four-wire SPI interface — not a high-pin-count parallel address bus/data bus arrangement — provides access to the ENC28J60's integrated MAC and 10BASE-T PHY. If you're familiar with the RTL8019AS and ASIX 88796 L Ethernet parts, you'll be right at home with the ENC28J60 as it uses configuration registers in the same manner as the RTL8019AS and ASIX 88796 L. In many ways, the ENC28J60 is easier to configure than the RTL8019AS. For the ENC28J60, full-duplex or half-duplex mode is sensed at power-up and there is no need for an external configuration EEPROM. The wiring of the ENC28J60's status LEDs determines which duplex mode the ENC28J60 will initially operate in.

A stock RTL8019AS contains a 16K internal buffer area, of which only 8K is available to our eight-bit micro-controller-based Ethernet designs. The ENC28J60 also incorporates 8K of internal buffer space. Buffer memory allocation within the ENC28J60 is logically identical to that of the RTL8019AS and ASIX 88796 L Ethernet parts. The internal transmit/receive buffer area is organized as a circular receive buffer area and a linear transmit buffer area. The similar buffer management schemes allow the ENC28J60 hardware to manage the flow of data from the 8K buffer area just like the RTL8019AS and ASIX 88796 L parts.

■ PHOTO 2. I HAD TO RESORT TO THE INCLUSION OF A BASE FRAMETHROWER MODULE AS I DIDN'T HAVE THE RAW SOCKETABLE COMPONENTRY TO BUILD UP THE ENC28J60 CIRCUITRY. I ALSO HAD TO ADD AN ADDITIONAL 3.3-VOLT REGULATOR, A 74HC125 LEVEL SHIFTER/BUFFER, A 32KBYTE EEPROM, SOME LEDS, A PUSHBUTTON SWITCH, AND SOME WIRE. I ALSO EXCHANGED THE DIGITAL FILTER'S 40 MHZ OSCILLATOR FOR A 20 MHZ VERSION AND SWAPPED IN A PIC18LF4620 FOR THE PIC18F452.



The ENC28J60 is a 3.3-volt part and requires a 25 MHz clock. If you plan on incorporating an ENC28J60 into a five-volt design, no problem as the ENC28J60 inputs are all five-volt tolerant. The SPI data out pin (SO), the two ENC28J60 interrupt outputs (INT and WOL), and the CLKOUT output are not five-volt compatible outputs and must be level shifted to work with five-volt systems. The voltage level shifting can be performed with standard HC or AHC logic. A 74HC125 is a good choice for a ENC28J60 level shifter/buffer. In fact, the 74HC125 will be used when I show you how to convert that Digital Filter to an Easy Ethernet/FT

Some of the ENC28J60's internal circuitry operates at 2.5 volts. Normally, that would mean the hardware designer would have to include extra circuitry to provide the 2.5 volt supply. The extra voltage regulation circuitry is not necessary as an on-chip 2.5-volt regulator is activated by connecting a 10uF capacitor to pin 1 of the ENC28J60.

I don't like to quote datasheets in my articles. You're an intelligent reader and you know that you can get the ENC28J60 datasheet from the Microchip website and absorb it offline if you feel that you need a bit more information. Hopefully, after my brief introduction to the ENC28J60, you have a general idea of what the ENC28J60 is all about. With that, let's move on and study the Easy Ethernet/FT circuitry depicted in Schematic 1 in detail.

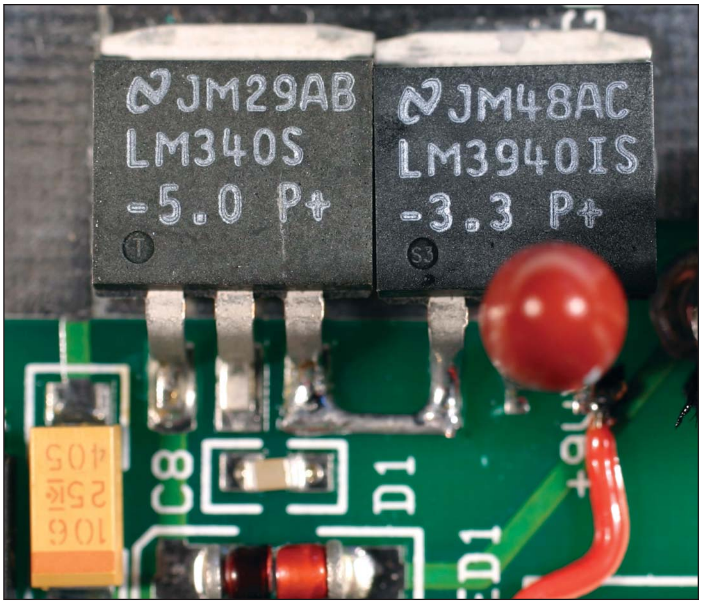
THE EASY ETHERNET/FT

When it comes to hardware design, I like to keep things as simple and basic as possible. The number of open I/O pins on the PIC18LF4620 supports my "keep it simple" policy. The Easy Ethernet/FT serial port is not at all complicated either and incorporates a minimal number of parts while providing true RS-232 voltages.

The 25LC256 SPI EEPROM is a 32Kbyte device that is used by the Microchip TCP/IP stack. The 25LC256 can be accessed on the LAN via FTP or serially by way of the Easy Ethernet/FT's serial port.

The trio of LEDs is really just eye candy. However, they do come in handy when you need a visual cue from

■ **PHOTO 3.** IN THIS SHOT, YOU'RE LOOKING DOWN ON THE 47UF TANTALUM FILTER CAPACITOR THAT IS ATTACHED TO THE NEWLY ADDED LM3940IS-3.3 VOLTAGE REGULATOR. I JUST TIED THE OUTPUT OF THE FIVE-VOLT LM340 INTO THE INPUT AND THE 3.3-VOLT LM3940, AND SOLDERED THE 47UF TANTALUM TO THE LM3940'S OUTPUT AND GROUND PINS. BANG! INSTANT 3.3 VOLT POWER SUPPLY RAIL FOR THE ENC28J60 ELECTRONICS.



the firmware. One of the LEDs is used as a heartbeat signal by the Microchip TCP/IP stack. The remaining LEDs are used in a demo web page control application that comes with the stack.

That pretty much covers the Easy Ethernet/FT's commodity circuitry. So, let's talk a bit more about the ENC28J60 and its immediate support circuitry. To reduce parts count, you could drive your microcontroller's clock input with the ENC28J60 CLKOUT pin. The output frequency of the ENC28J60's CLKOUT pin is under the control of the ENC28J60's ECOCON register. The ECOCON configuration bits allow the CLKOUT output to be divided by 2, 3, 4, or 8. The clock division provides CLKOUT signals of 12.5 MHz, 8.333333 MHz, 6.25 MHz, and 3.125 MHz, respectively. The CLKOUT pin provides a 25 MHz clock signal with no clock division. The CLKOUT pin signal can also be disabled, which drives the CLKOUT pin to a logical low state. The CLKOUT function is disabled in the Easy Ethernet/FT application.

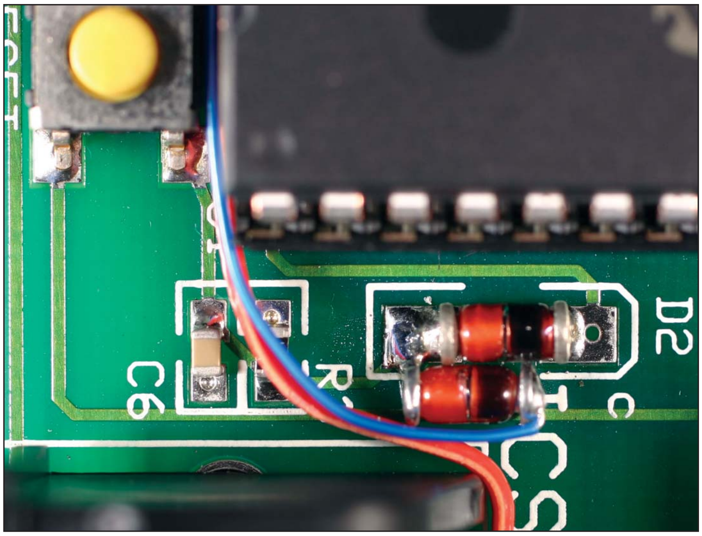
Note that the ENC28J60's INT pin and WOL (Wake-up On LAN) pin are connected to the PIC18LF4620's external interrupt pins RB0 and RB1. If the interrupt is not related to Wake-up on LAN, it is presented via the ENC28J60's INT pin. The WOL pin is primarily intended to awaken the host when one of the WOL interrupt types occurs. These pins are not five-volt tolerant and require a three-volt-to-five-volt level shifter in five-volt systems.

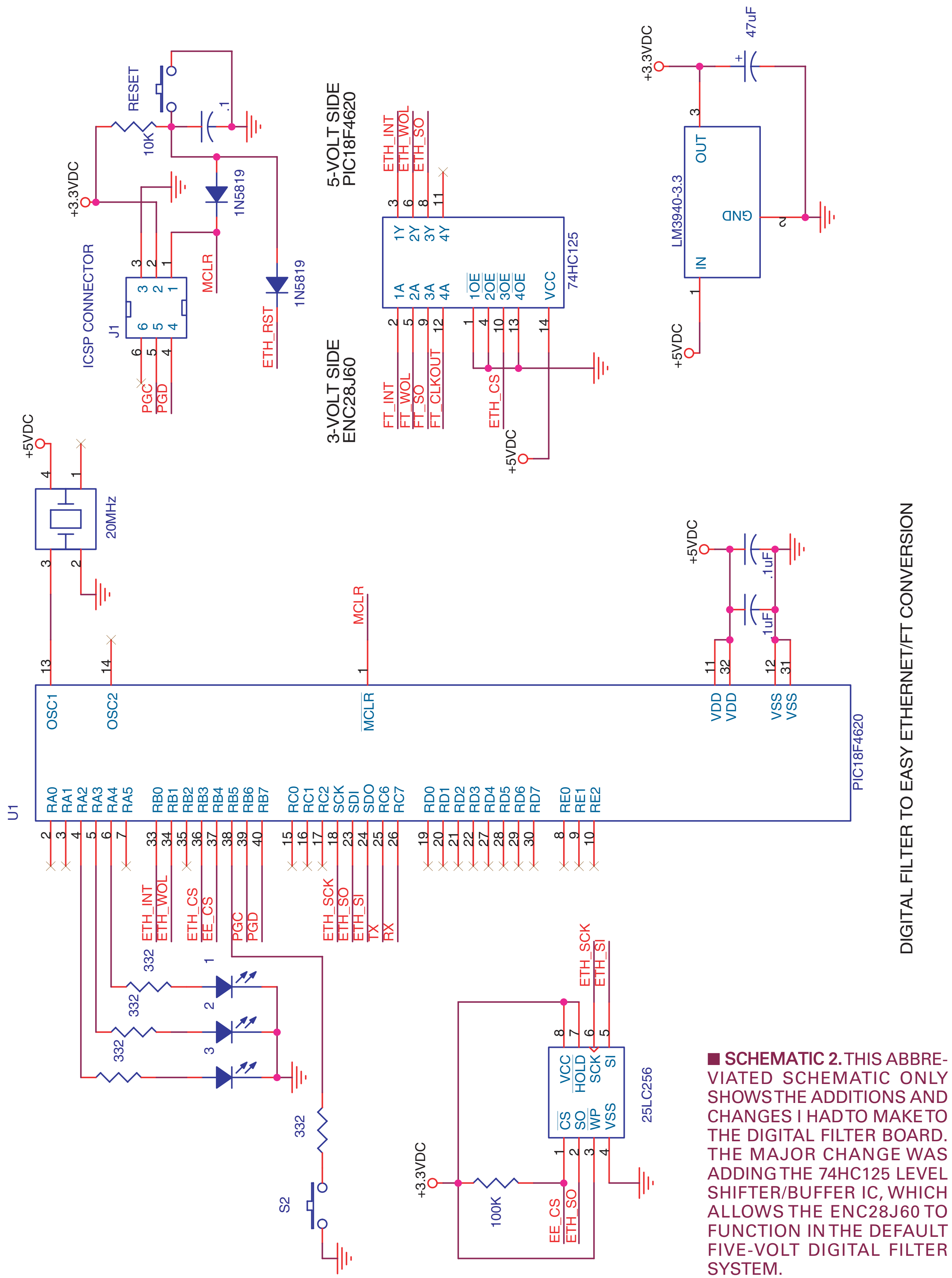
Pins SO, SI, SCK, and CS form the ENC28J60's SPI interface, which is always operated in slave node. Recall that only ENC28J60 input pins are five-volt tolerant. The ENC28J60 SO pin performs the SPI slave output function and is the only non-five-volt tolerant SPI interface pin.

The ENC28J60 is unique in that many of the operations on the ENC28J60's internal registers are very similar to that of a microcontroller. The ENC28J60's active-low, five-volt tolerant RESET pin is identical in operation to a standard microcontroller RESET input. You can include a standard microcontroller reset circuit for the ENC28J60's RESET pin in your design, tie the ENC28J60 RESET line to a microcontroller I/O line, or use the reset signal from the existing microcontroller reset circuitry. The simplest method of resetting the ENC28J60 is to use the existing microcontroller reset circuitry. Diode D3 routes the PIC18LF4620's reset signal to the ENC28J60 RESET pin.

Pins 12 and 13 are the ENC28J60's differential receive pins. TPIN+ and TPIN- are connected to the 1:1 10BASE-T pulse transformer. The pair of 49.9Ω precision resistors and the .01µF capacitor are required for proper termination. TPOUT+ and TPOUT- are the ENC28J60's differential transmit pins that interface to the transmit side of the ENC28J60's PHY to the 1:1 10BASE-T-rated pulse transformer. Termination on the transmit side is again supplied by a pair of 49.9Ω precision resistors and a .01µF capacitor. The center tap of the transmit side of the pulse transformer receives power through a high-current 60Ω ferrite bead, which helps to filter out any extraneous noise that could make its way into the Easy Ethernet/FT's power supply. The term "differential" is synonymous with analog and like digital circuitry, analog circuits need power too. The 2KΩ precision resistor attached to the ENC28J60's RBIAS pin activates the ENC28J60's internal analog circuitry.

■ **PHOTO 4.** THESE LITTLE BUGGERS TEND TO ROLL AROUND WHEN YOU DON'T WANT THEM TO. HOWEVER, A QUICK SHOT OF SOLDER PUTS ON THE BRAKES. NOTE THAT I'M SIMPLY PULLING THE EXISTING MICROCONTROLLER RESET VOLTAGE THROUGH THE ADDED DIODE AND FEEDING IT TO THE ENC28J60 RESET PIN.

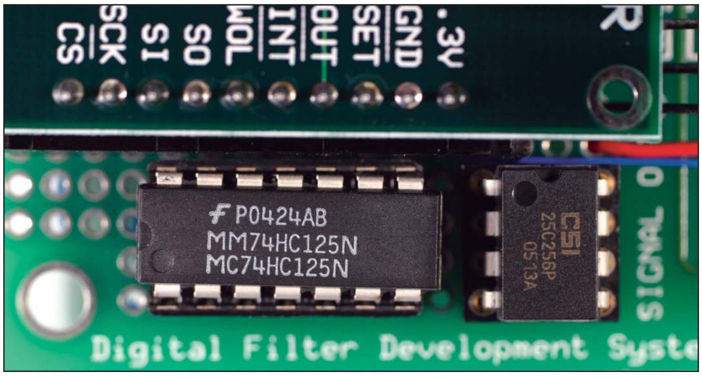




■ **SCHEMATIC 2.** THIS ABBREVIATED SCHEMATIC ONLY SHOWS THE ADDITIONS AND CHANGES I HAD TO MAKE TO THE DIGITAL FILTER BOARD. THE MAJOR CHANGE WAS ADDING THE 74HC125 LEVEL SHIFTER/BUFFER IC, WHICH ALLOWS THE ENC28J60 TO FUNCTION IN THE DEFAULT FIVE-VOLT DIGITAL FILTER SYSTEM.

LEDA and LEDB are dancing chickens under the control of bits in an ENC28J60 internal register. LEDB is configured by bits in the PHLCON register, which allow LEDB to display transmit activity, receive activity, collision activity, link status, or duplex status. For visual error reporting or status, LEDB can be configured to blink at a fast or slow rate. The most intriguing function of LEDB is associated with duplex modes. If the ENC28J60 LEDB pin sources current to the attached status LED, half-duplex mode is selected. On the other hand, if the LEDB pin is sinking status LED current, full-duplex mode is activated. LEDA can be configured for the same operations as LEDB, but LEDA has no control over any ENC28J60 configuration processes. Resistors R11 and R12 perform the current limiting function for LEDB and LEDA, respectively. Note that the ENC28J60's LEDB pin is sourcing current by default on the Easy Ethernet/FT putting the Easy Ethernet/FT in half-duplex mode. The Easy Ethernet/FT design uses a Bel Stewart MagJack 0810-1X1T-36 10BASE-T pulse transformer.

That just about does it as far as a logical view of the ENC28J60 is concerned. The parts in the Easy Ethernet/FT schematic I've just described come alive in Photo 1 to form a physical Easy Ethernet/FT module.



■ PHOTO 5. NOTICE THE 10 FRAME THROWER INTERCONNECTS JUST ABOVE THE 74HC125 AND 25C256 EEPROM. ADDING THE 74HC125 LEVEL SHIFTER/BUFFER WAS A LOT LESS WORK THAN CONVERTING THE DIGITAL FILTER'S FIVE-VOLT POWER RAIL TO A 3.3-VOLT POWER RAIL. BY LEAVING THE ORIGINAL DIGITAL FILTER FIVE-VOLT POWER RAIL INTACT, I ONLY HAD TO ADD THE 74HC125 AND I DIDN'T HAVE TO TEAR UP THE DIGITAL FILTER'S PRINTED CIRCUIT BOARD TRACES AND ADD A 3.3-VOLT RS-232 IC.

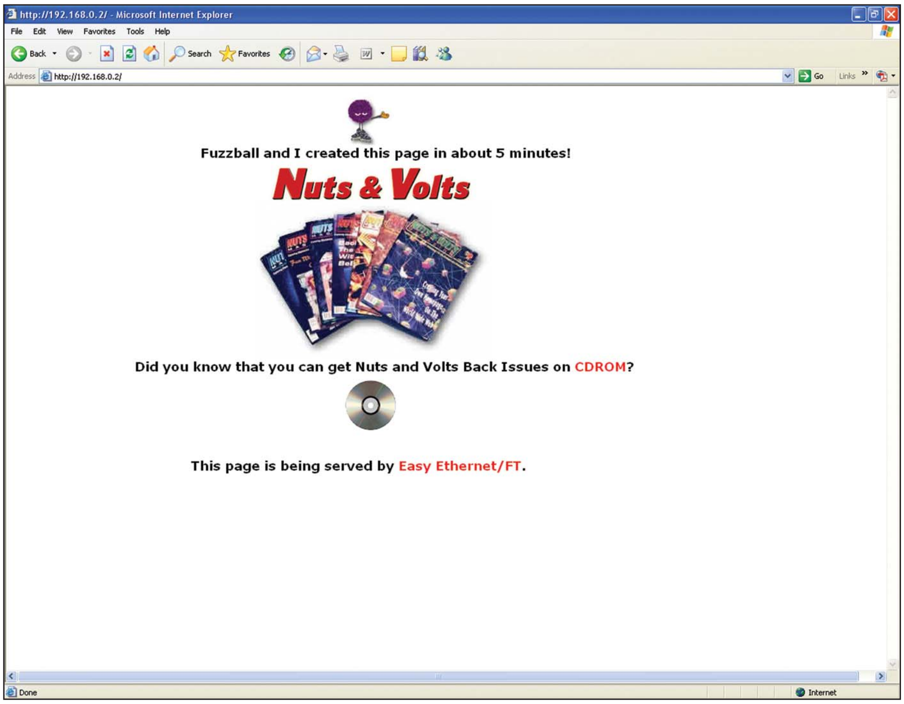
DIGITAL FILTER TO EASY ETHERNET/FT CONVERSION

The Easy Ethernet/FT's simplistic design and the availability of a professionally prefabricated Easy Ethernet/FT printed circuit board result in an Ethernet-based project that is very easy to assemble. If you choose to "scratch" an Easy Ethernet/FT or convert an existing project to an Easy Ethernet/FT, you'll find that to be an easy task as well, as the ENC28J60 only requires nine connections — including power — for full integration into your existing circuitry. The electronic module you see in Photo 2 is a fully functional Easy Ethernet/FT on a Digital Filter frame. Let's talk about how I pulled that off.

There's plenty of room in the Digital Filter's breadboard area to mount a 28-pin DIP version of the ENC28J60 and the supporting circuitry. However, I didn't have a DIP version of the ENC28J60. So, I relied on the services of a base Frame Thrower module that was loaded with an ENC28J60 in an SOIC package. The Frame Thrower module circuitry is identical to the ENC28J60 circuitry found on the Easy Ethernet/FT. However, the base Frame Thrower module doesn't contain an EEPROM or the extra RESET diode.

The Sipex SP233ACP RS-232 IC is a five-volt part. I really didn't want to try to squeeze in a three-volt equivalent. So, the Digital Filter board's original five-volt components will all remain as they are. Despite my inability (unwillingness) to change the RS-232 component to a three-volt part, I was able to swap in a heftier microcontroller in the PIC18LF4620 and changing the original 40 MHz oscillator out for a 20 MHz oscillator was a snap.

Since I had put myself in a dual-voltage situation, I went about creating the +3.3-volt power supply required



■ PHOTO 6. PULLING OFF THIS WEB PAGE WAS A SNAP. WHEN YOU CREATE YOUR PAGES, MAKE SURE YOU DON'T EXCEED THE 32KBYTE LIMIT OF THE EEPROM.

by the ENC28J60. The LM3940IS-3.3 is designed to hang behind a five-volt regulator like the LM340S-5.0 and provide a second +3.3VDC power rail. As you can see in Photo 3, I simply nudged the LM3940 in beside the existing LM340 and added the required 47µF filter capacitor on the LM3940's output pin. An elegant strand of red ribbon cable delivers the 3.3-volt power rail to the ENC28J60 area of the printed circuit board.

I knew that I had to add the extra ENC28J60 RESET line diode sooner or later and I figured it would be best to do it sooner before I got into wiring in the Frame Thrower module. A close look at the diode set in Photo 4 shows that I oh-so-carefully attached the extra RESET steering diode to the existing MCLR blocking diode at their anode ends. I pulled off the ENC28J60 RESET signal from the newly added diode's cathode terminal. Piece of cake! Remember, the ENC28J60 RESET line is five-volt tolerant and does not require any buffering or level conversion.

The next step in the conversion involved adding the 74HC125 level shifter/buffer IC. As you can see in Schematic 2, I buffered all of the ENC28J60's outputs including the CLKOUT signal, which I left open on the output of the 74HC125 just in case I decided to use it for something. In addition to showing you the location of the 74HC125, Photo 5 also contains a shot of the socketed 25C256 3.3-volt SPI EEPROM. If you're wondering where the power supply bypass capacitors are for the 74HC125 and the EEPROM, they're 0805 SMT components that are mounted on the pin side of the Digital Filter printed circuit board.

After wiring in the base Frame Thrower module through the 74HC125, all that was left to do was to add the LEDs and a pushbutton switch. The LEDs and the switch are used by the demo program that comes with the free Microchip TCP/IP stack. I performed a quick check of my wiring and applied power without any of the new silicon mounted in the Digital Filter's sockets. The voltages were at the correct levels and on the correct pins. So, I installed all of the new ICs and the base Frame Thrower module. Once again, I applied power to the newly converted Easy Ethernet/FT. No smoke and the

voltages were up to spec. That can only mean one thing — it's time to load some TCP/IP stack firmware and see what happens.

AT YOUR SERVICE

Before loading the Microchip TCP/IP stack, there are a couple of things we need to do. The Microchip TCP/IP stack assumes a 10 MHz clock is driving the PIC18F4620. I didn't have any 10 MHz oscillators or crystals lying around. So, I went with what I could find in the shop — a 20 MHz five-volt oscillator. Since the Microchip stack calculates timings and baud rates from a clock speed variable (*CLOCK_FREQ*), I simply made the clock speed change in the *Compiler.h* code module by changing the *CLOCK_FREQ* value to match my new oscillator speed.

From previous experience with the ENC28J60, I know that I have to slow down the SPI clock one click from FOSC/4 to FOSC/16 at 20 MHz. This is easily done in the *ENC28J60.c* stack module by changing SSPCON1's value from 0x20 to 0x21 in the *MACinit* function.

The Microchip TCP/IP stack with the ENC28J60 module is already set up with the PIC18LF4620 configuration fuse settings. So, I kicked off a compile, which completed successfully, and loaded up the PIC18F4620 on the newly converted Easy Ethernet/FT. When things are good, one of the LEDs flashes about once per second telling you that the TCP/IP stack code is running. When I saw the flashing LED, I noted the IP address that had been assigned to the new Easy Ethernet/FT module via a connection to the converted Easy Ethernet/FT's serial port. I PINGED the displayed IP address and got return replies as expected. It's alive!

Now it's time to have some fun. I whipped up a little web page and used the Microchip MPFS program, which comes with the stack, to convert the HTML into a downloadable binary image. Using FTP, I loaded the web page into the converted Easy Ethernet/FT's 25C256 EEPROM. All went well. In fact, it went *very* well as you can see the results of my labor in Photo 6. By the way, I didn't write any code other than making the changes in the TCP/IP stack modules. How about that!

I'm sure you're going to want to include the ENC28J60 into your Design Cycle before too long. So, if you have any problems finding stuff you need to get your ENC28J60 project up and running, just let me know and I'll do my best to help you out. ■

SOURCES:

MICROCHIP — **www.microchip.com**
- ENC28J60
- Microchip TCP/IP Stack
- PIC18LF4620

CBS, NBC TO OFFER TV SHOWS FOR 99 CENTS

CBS and NBC have announced deals to offer replays of prime-time programs for 99 cents per episode, shifting television toward a sales model that gained popularity with downloaded music.

CBS is teaming up with Comcast Corp. and NBC with satellite operator DirecTV to offer the on-demand replays.

NBC Universal will offer commercial-free episodes of "Law & Order: SVU" and other shows to subscribers of DirecTV Group, Inc., who use the satellite company's new digital video recorder.

Comcast's on-demand customers in some markets will be able to view "CSI: Crime Scene Investigation," "NCIS," "Survivor," and "The Amazing Race" at their convenience.

"This is an incredibly exciting evolution for CBS and network television — video on demand is the next frontier for our industry," CBS Chairman Leslie Moonves said of the deal with Philadelphia-based Comcast, the nation's largest cable systems operator. CBS, which is owned by Viacom Inc., announced last week it would stream episodes of its show "Threshold" over CBS.com.

The Walt Disney Co.'s ABC network offers downloads of several programs, including "Desperate Housewives" and "Lost," for $1.99 each via iTunes software from Apple Computer, Inc.

Comcast's service will be available starting in January to customers in markets with a CBS owned-and-operated television station, which includes the nation's seven largest media markets. The episodes will be available as early as midnight following a broadcast and will include commercials.

The DirecTV agreement includes shows that air on NBC, USA, Bravo, and the Sci-Fi Channel, including "The Office" and "Monk." Episodes of the shows will remain available for one week after their broadcast. NBC Universal is a unit of General Electric Co.

ONLINE ID THEFT WORSENS, SCARES US BANK CUSTOMERS

Even as banks and regulators step up efforts to thwart identity theft over the Internet, the worry that fraudsters remain one step ahead is convincing many Americans that banking online is too risky.

At a recent identity theft forum in New York, security and policy experts said banks are taking appropriate steps to stop online criminals, but that their best efforts — and consumers' own vigilance — may not be enough.

"Consumers can do everything right — not give out passwords or financial information — and still become victims," said Susanna Montezemolo, a policy analyst at Consumers Union, in an interview.

A survey commissioned by Internet security company Entrust, Inc., found that 18 percent of Americans who have banked online now do so less, or not at all, because of security concerns. Ninety-four percent say they're willing to accept extra online security protections.

Some 10 million Americans are ID theft victims each year, the Federal Trade Commission estimates.

WORM TARGETS LINUX SYSTEMS

A new worm that attacks Linux systems and exploits several vulnerabilities in the operating system has been reported, and security firms are urging caution among users.

The worm has been dubbed "Lupper" by antivirus firm McAfee and "Plupii" by Symantec. Threat levels range from low to medium risk among security companies, mainly because the worm has not been distributed widely.

Although its threat rating is low, the worm is being watched for its potential to hurt Linux systems. It installs a backdoor on infected servers, which then can be exploited to create a network of systems that can launch attacks on other computers.

According to McAfee, the worm spreads by exploiting Web servers hosting vulnerable PHP/CGI scripts. It is a modified derivative of the Slapper and Scalper worms, which targeted Linux and BSD, respectively.

The worm blindly attacks Web servers by sending malicious HTTP requests on port 80, McAfee noted in its advisory.

"If the target server is running one of the vulnerable scripts at specific URLs and is configured to permit external shell commands and remote file download in the PHP/CGI environment, a copy of the worm could be downloaded and executed," the advisory states.

Similar to Slapper and Scalper, the new worm creates a network of compromised servers based on peer-to-peer principles. This network could be used for denial-of-service attacks, McAfee warned.

IPOD CLASS ACTION LAWSUIT GOES INTERNATIONAL

Lawyers representing users of a class action lawsuit filed in the United States that purchased iPod nanos have now filed suits on behalf of users in the United Kingdom and Mexico in the United States District Court for the Northern District of California.

Both lawsuits claim the iPod nano is defective in its design, which allows the screen to become scratched under normal use. Lawyers are claiming that Apple knew of the iPod nano's design flaw but chose to ignore it in an effort to speed the product to market.

The lawsuit claims the defect is a result of a much thinner layer of resin used in designing the nano that does not provide adequate protection from scratching.

The lead attorney on the case claims that the international suit was launched due to a large number of international requests.

"Apple's iPod Nano has sold in record numbers around the world,

just as it did in the US," said Steve Berman, the lawyer representing iPod owners. "It seems that wherever the nano is sold, problems with the defective design soon follow. The far-reaching response also reveals that this is not just a small problem or a bad batch of nanos, but a defect in the overall design that should have been rectified prior to the release."

The suit seeks to represent and recover money lost for all those who live outside of the United States who purchased an iPod Nano.

FCC CLARIFIED VOIP DISCONNECTION DEADLINE

The Federal Communications Commission (FCC) won't be requiring Internet phone service providers to cut off customers who don't have reliable 911 emergency call service.

The agency said providers that had not achieved full 911 compliance by the November deadline will not be forced to discontinue such service to any existing customers.

At the same time, the FCC said it expected providers to discontinue marketing Internet call service and accepting new customers in areas where the companies are not routing 911 calls to emergency response centers.

Last May, the FCC ordered providers of Internet-based phone calls to certify that their customers will be able to reach an emergency dispatcher when they call 911. Dispatchers also must be able to identify the caller's phone number and location.

The FCC issued the order after a series of highly publicized incidents in which Internet phone users were unable to connect with a live emergency dispatch operator when calling 911.

GROKSTER POWERS DOWN AFTER SUPREME COURT RULING

Grokster, the embattled file-sharing website that critics derided as a hive of copyright infringement, announced it was throwing in the towel. The company shut down operations and agreed to settle the piracy case filed by the Motion Picture Association of America and the Recording Industry Association of America.

Grokster has agreed to stop its practices and to pay some $50 million in damages.

The decision came as a surprise to peer-to-peer (P2P) users who visited the site to find a message stating that the US Supreme Court had unanimously determined that the service was illegal. The website directed users to seek out legal downloading services. ■

TECH FORUM

This is a READER-TO-READER Column.

All questions *AND* answers are submitted by *Nuts & Volts* readers and are intended to promote the exchange of ideas and provide assistance for solving problems of a technical nature. Questions are subject to editing and will be published on a space available basis if deemed suitable by the publisher. Answers are submitted by readers and NO GUARANTEES WHATSOEVER are made by the publisher. The implementation of any answer printed in this column may require varying degrees of technical experience and should only be attempted by qualified individuals. Always use common sense and good judgement!

All questions and answers should be sent by email to forum@nuts-volts.com All *diagrams should be computer generated and sent with with your submission as an attachment.*

QUESTIONS

To be considered, all questions should relate to one or more of the following:

❶ Circuit Design
❷ Electronic Theory
❸ Problem Solving
❹ Other Similar Topics

■ Be brief but include all pertinent information. If no one knows what you're asking, you won't get any response (and we probably won't print it either).
■ Include your Name, Address, Phone Number, and Email. Only your Name, City, and State will be published with the question, but we may need to contact you.
■ No questions will be accepted that offer equipment for sale or equipment wanted to buy.
■ Selected questions will be printed one time on a space available basis.
■ Questions are subject to editing.

ANSWERS

■ Include in the subject line of your email, the question number that appears directly below the question you are responding to.
■ Payment of $25.00 will be sent if your answer is printed. Be sure to include your mailing address or we can not send payment.
■ Only your Name, City, and State, will be printed, unless you say otherwise. If you want your email address included, indicate to that effect.
■ Comments regarding answers printed in this column may be printed in the Reader Feedback section if space allows.

>>> QUESTIONS

With more people building computers for their cars, one thing that is still missing is a sensitive FM stereo — and perhaps AM too — radio tuner that can be controlled by the PC.

There are several units such as the D-Link FM USB tuner, which is now out of production, and the new radioShark which is now one of the only AM-FM USB tuners available. All of these suffer from the same problem in that they don't work well in a car. They just seem to pick up very few stations even when connected to the car's antenna. I have also tried one called the radioXtreme which still is quite poor and got even worse reception when I tried to use an FM antenna signal amplifier. So to get to my question ...

1) Why does a $9.95 transistor radio with a little antenna get better reception than a USB radio costing many times as much?

2) How can I build my own PC radio that IS sensitive and will work in a car?

#12051 ■ *David Delman.Jericho, NY*
nv@tvpedaler.com

I have some 4559 aircraft landing lights, they are 28 volt 600 watt. I was hoping to use them for some concert lighting I do. But, I haven't come up with a way to power them, being that I need a 28 volt 21.5 amp power supply (I assume AC or DC will work).

I would like something that can just plug into the wall; dimmable would be nice. I tried an off-the-shelf standard home dimmer, carefully setting it (low) to 12V-15V, but it just blew the bulb. Light weight and cheap are definite pluses in its design.

#12052 ■ *Brandon Spivey, Nashville, TN*

I have a control arm that moves up and down, pulling a cable. I would like to place in a remote site, a series of LEDs that indicate the position of the arm. How can I convert the movement of the cable or arm to activate the LEDs in relation to the arm/cable?

#12053 ■ *Charlie Willwerth*
St Augustine, FL

Fate has left me with many computer boards and parts. I am intrigued with the potential of using the memory planes in alternative engineering. I have an old Heath u-processor trainer for a pattern and am wondering if anyone has tried anything like that before. Feedback from the experienced only desired.

#12054 ■ *Robert Gibson*
nosyroby@aol.com

I am an avid reader of *Nuts & Volts*, and love every issue. I am building the MP3 player project and have come across a slight problem: I don't want to pay for a VFD but want an interesting display. So I searched around a bit and found a cheap color display (**http://store.earthlcd.com/s.nl/sc.7/category.427/it.A/id.4097/.f**), but the design of the MP3 won't use all of the display's great capabilities, nor is it compatible. My idea was to use another microprocessor to create graphics and use LCD data from the MP3 player to show the play info. A display adaptor. But I'm unsure where to start. I have an idea on how the software will work, but I don't really know what microprocessor to use. It needs to be able to interpret data, display color, and be compatible.

#12055 ■ *Andrew via internet*

>>>> ANSWERS

[#09053 - September 2005]

Is there an LED circuit to show when a sealed, wall-wart type charger is actually putting out a charge to a battery? It would have to be wired into the output cord. I don't want it to merely show that power is available but should light only when actually charging the battery.

I was faced with a similar dilemma years ago. My cordless soldering iron sat in a charging stand and sometimes the charging pins on the soldering iron didn't make good contact with the connectors in the base. The result was the soldering iron could sit in the stand for days and when I went to use it, it would not be charged. The solution was to break the positive lead between the wall wart power supply and the positive connecting pin in the charger stand (this was done inside the charging stand) and parallel a suitable resistor with a red LED which I mounted on the front panel of the

[#09055 - September 2005]

Can someone PLEASE provide schematics for a Phone Amplifier built around the LM386 chip, working from a 9 VDC @ 200 mA, providing lots of volume through an eight-ohm speaker and, at the other end, having a universal phone pick-up with a suction cup, which attaches to the earpiece side of the phone handset?

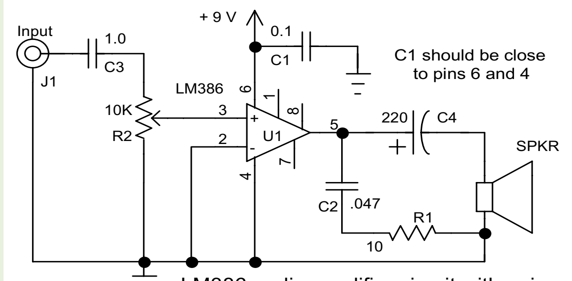
#1 RadioShack sells or sold until very recently, exactly what you want as part #277-1008C, a nine-volt 200 mA LM386 based amplifier complete — which is very close to the LM386 datasheet schematic for a 200 dB amplifier — and includes the input jack for the pickup coil. The datasheet with the schematic can be found at: **www.national.com/pf/LM/LM386.html**

William Como, Bethpage NY

#2 Here are two schematics for the LM386. C1 prevents possible oscillation if there are long wires or traces (over three or four inches) to the power source, or if a battery power source is weak.

C6 in the high gain circuit is not always used, but is used in the circuits in the manufacturers' data sheet circuits, so I always use it. Probably the high-gain circuit will be needed; it should work with most telephone pickups.

Bill Stiles, Hillsboro, MO



LM386 audio amplifier circuit with gain of 20, minimum parts count Fig. 1.

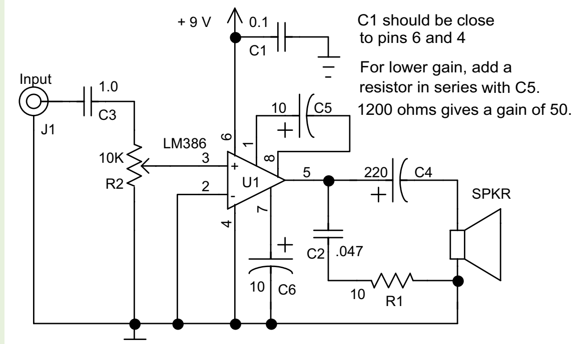
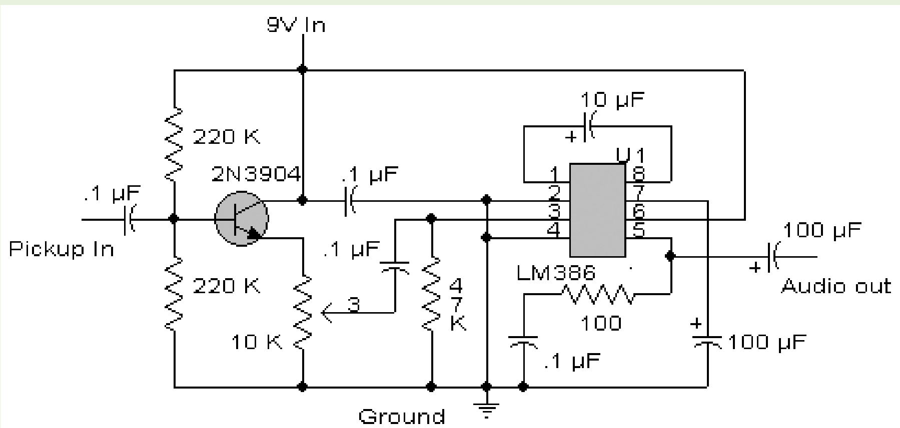


Fig. 2. LM386 circuit with gain of 200.

#3 The circuit below is not perfect, but, I find it to be an acceptable solution. Simply connect a coil pickup between "pickup in" and ground, then attach an eight-ohm speaker between "audio out" and ground, and hook up a 9V battery and you're set. The 10 µF electrolytic capacitor on pins 1 and 8 of the LM386 is what controls gain (datasheet specifies 10 µF as the maximum allowable value). The 10K potentiometer is for volume control. Good luck!

Kevin Harris, St Peters, MO



charging stand. The charger only delivered about 100 mA of charging current so the iron could sit on the stand indefinitely without cooking the battery. The unloaded voltage of the power pack was five volts so I reasoned that about 90 mA of the charging current had to flow through a suitable resistor and the other 10 mA would flow through the LED to illuminate it. A 68Ω, five-watt resistor in parallel with the LED worked out just fine and I now just wriggle the iron in the base until the LED glows to know the iron is recharging. I have used this arrangement with the same cordless soldering iron for over 15 years! The resistor/LED combo could be mounted in a small pill bottle or small piece of PVC tubing glued to the wall wart (with the resistor spaced away from the plastic sides). Two components. It doesn't get much simpler than that!

Bud Wintcher, Colorado Springs, CO

[#09054 - September 2005]

I need a low power IR receiver (<=100 μA) for bi-directional communications. I've thought about using a pin diode but they require a fair amount of bias current.

This will not be useful for beyond 1 MHz base bandwidth, such as video cameras.

Parts suggested: IR Photodiode and CMOS CD4049 hex inverter. Because the power supply pins are on the same side of the chip, you can use only one side, but you may want to ground the three inverters on the other side.

Connect three inverters that you will use as if they were inverting op-amps, using 1K resistors on the inputs and 100K resistors for feedback. Run the chip at a low voltage, like three volts. Ground one side of the photodiode, and couple it to the first input with a capacitor.

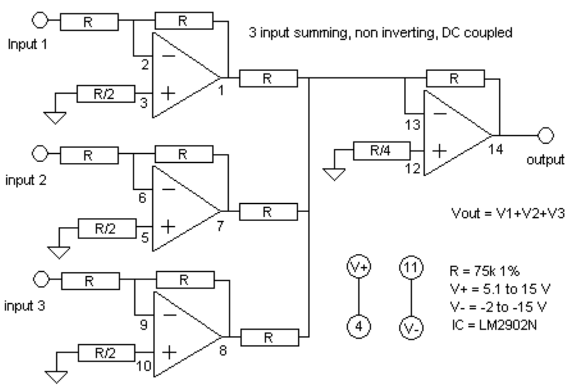
It may help to add a 100K or higher resistor between + and the photodiode. Your signal simply comes out the last inverter. If it's digital, feed it into another inverter or two, to make it unambiguously logical instead of analog. Note: The 4049 chip does exhibit an analog response, other similar ones do not.

William Como, Bethpage, NY

[#10054 - October 2005]

I am looking for a circuit that will sum three analog signals to one output. The three inputs are DC, vary from 0 to 1.2 volts, and vary at 0 to 100 Hz. I believe I should isolate the inputs more than with just a simple resistor network. Is there a three-input mixer or amplifier IC that would do this? I'm also open to a discrete-component solution, and would appreciate any suggestions.

#1 What you need is a three input, DC coupled summing chip, with an output buffer, commonly known as a "quad op-amp."



You will need a chip that can provide enough accuracy and sensitivity, and enough output current to drive the next stage. The value of R is determined by the input requirements of the op-amp, the accuracy you need, and sometimes, the impedance of the signal to be amplified. For example, let's suppose you need 5% accuracy and budget accordingly. If the input signal loads down by 1% when delivering 1 milliamp of current, the lowest value of R must be 1,200 ohms (R=1.2V/.001A). This is a two-stage amplifier, so each stage is allowed 2% error. Using 1% resistors leaves 1% for the Input Offset Voltage of the op-amp plus the Input Offset Current times R/2. One percent of 1.2 volts is .012 volts. Only chips with less than 12 millivolts of offset voltage will work. Using www.mouser.com to look up spec sheets, search for "quad operational amplifier" and find the cheapest one available. LM2902N costs 32 cents. Under "typical" conditions, it has a two millivolt input offset voltage, and two nanoamps of offset current. It also needs at least 5.1 volts of positive supply voltage in order to output 3.6 volts at 10 mA. Here we meet a typical problem with single supply op-amps: it cannot deliver less than 20 millivolts without a negative supply voltage. In this circuit, three input amplifiers delivering 20 mV to the summing stage will force it to output 60 mV when the inputs are all at zero volts. That is 5% error all by itself, and the only cure is to provide a negative supply of at least two volts. Raising the value of R to 75K (no change in cost) reduces the input loading to .19 mV and raises the value of Offset Bias Current x R to .15 mV.

For a typical LM2902N, the sum of all errors is .016% from loading the source signal, plus 2% for resistors, plus 1/3% as input offset voltage, plus .013% (from Ibias x R) = 2.36%. Very nice results for a 32-cent chip.

C. L. Larson, Largo, FL

#2 This is a discrete component solution. Most audio mixers will be AC coupled and will not meet your needs. The inputs are isolated by the virtual ground at the op-amp input.

Figure 1 is the schematic. V3, V4, and V5 are the input signals, which are ramps programmed to be different times so the effect can be seen on the output.

Figure 2 shows the three ramps and the summed output. I used a

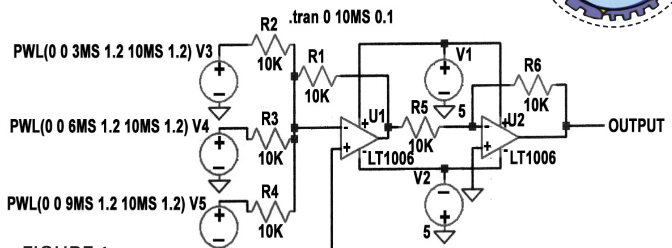


FIGURE 1

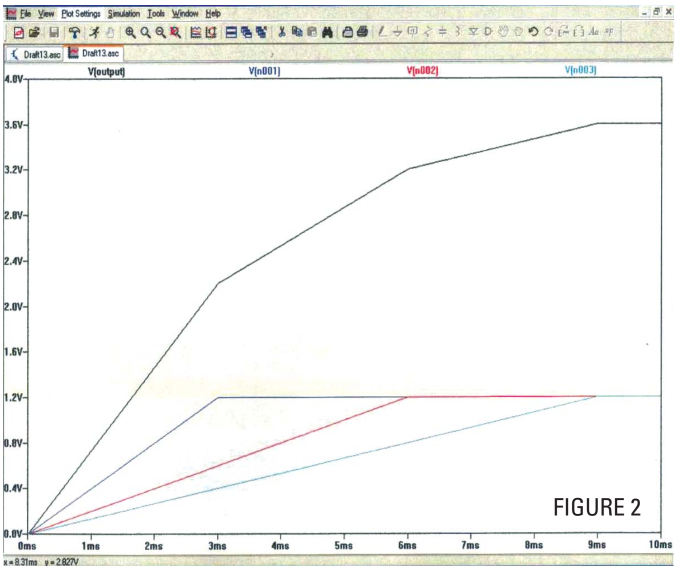


FIGURE 2

five-volt power supply but any higher voltage up to the rating of the op-amp will work. I would have used an LM358 op-amp, but it was not in the library.

Russ Kincaid, Milford, NH

[#11059 - November 2005]

I have a neon light power transformer. Input is 120V, output is 7,500V @ 30 mA. The output is powering an ozone generator that I built. I need to limit the power to the ozone generator. To vary the power output, do I place the limiter before or after the transformer? If before, would reducing the power shorten the transformer's life span? How do I go about adding a dial to limit the power to the ozone generator?

Try putting a three-way lamp with a 50-100-150 watt bulb in SERIES with the 120 volt side of the neon transformer. That gives you OFF-50W-100W-150W control. The bulb works as a ballast to limit the power. You may find that the ozone generator is using even less power than 50 watts, in which case the bulb will be dim or not even light up. If you are pulling more than 150 watts, the lamp will be about as bright as it would be in normal use and the project will be a success because the lamp will limit the ozone generator to your choice of 50-100-150 watts.

Understand that as described above, the ozone generator cannot use more power than the light bulb, which is in series with the PLUG-IN side of the

transformer, so you control the power limit by the bulb's wattage. You may use a higher wattage "ordinary bulb" lamp, if necessary.

A variable inductance or "VARI-AC autotransformer" may be used instead of the light bulbs, but they are usually very expensive and considered obsolete. They are very large, electrically clean, industrial-strength AC power-control knobs. It may also be possible to use ordinary transformers as chokes, and even vary their inductance by loading them, to control and reduce the power of the neon transformer. Be careful.

William Como, Bethpage, NY

[#11057 - November 2005]

I have an old Gateway Profile 2 all-in-one computer and would like to use the monitor for a video screen. How can I go about finding the pinout for the monitor connection, or better yet, how can I convert to a video screen?

Gateway has a rather extensive support site at **http://support.gateway.com/** and they don't have the tendency that some other companies do to delete information on products soon after they are discontinued. You can find the users guide for the Profile 2 online at **http://support.gateway.com/support/manlib/Profile/Profile2/Profile2.shtml**.

Looking in the users guide I see on the back view that there is no video input to the Profile 2. In fact, it doesn't even have the "legacy" PS/2 keyboard and mouse connectors, or serial or parallel ports. So it looks like using the Profile 2 screen as an LCD monitor would require disassembly of the machine and splicing into the video signals that go to the LCD.

However, the problem with this is that usually in all-in-one machines — such as the Profile series — you won't find a video card inside and a standard VGA cable going to the monitor internally, that you could disconnect and connect to another system externally. Because it is a closed system, they don't have to generate a standard analog VGA signal that is compatible with external monitors.

Instead, they run the digital signal from the video controller directly to the LCD controller chip. This saves a lot of electronics and cost by skipping the step of converting the digital signals from the VGA controller to an analog VGA signal only to have the LCD convert the signal back to digital again with analog to digital converters.

The result of this is that it will probably be difficult to convert the unit to an LCD monitor. But I would start with inspecting the motherboard and LCD controller to determine what kind of signals are being transferred. Just use your favorite Internet search engine to search the part numbers on the ICs, and look at the data sheet to see what signals those ICs produce. If you are lucky, it might be something standard like a digital DVI signal.

Carl D. Smith Jr., Fargo ND

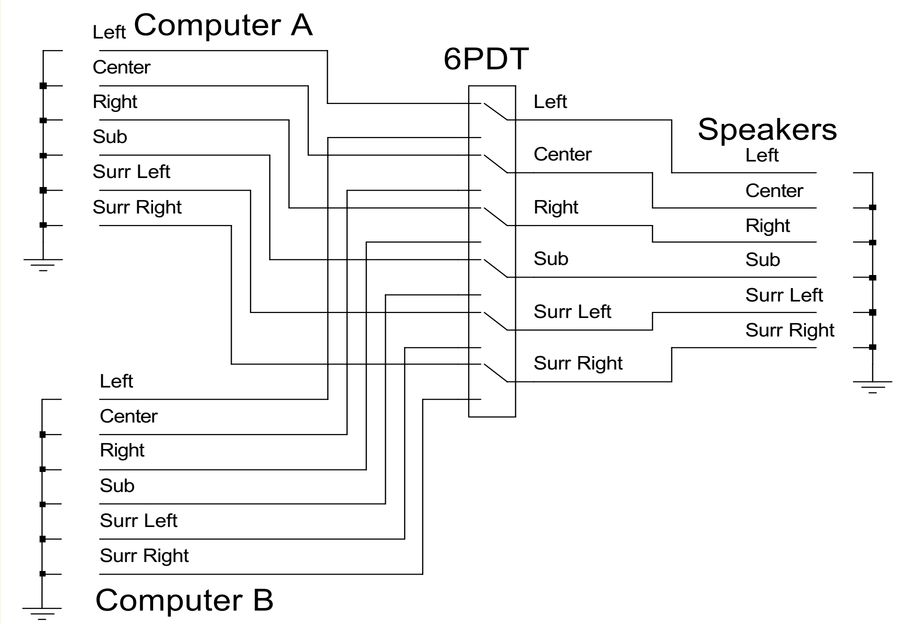
[#11051 - November 2005]

I'm trying to make an A/B switch that can be connected to two computers.

I want my 5.1 speakers to be shared by both computers without having to disconnect them. Can someone provide a schematic that I could build from?

A 5.1 (six channel) A-B Box can be a fairly simple construction project. The simplest form is to base the project around a 6PDT switch (six Pole, Double Throw). I like rotary switches like Mouser's #10YX062. It is a good switch I've used for many applications including audio. Pick a box, a knob, and either connectors for the box or wires to plug directly into the computer (I have found you can cheaply purchase pre-made 1/8" mini cable or RCA cable and cut off one end to wire to the switch). I have included a schematic but construction is simple. For example, just tie the positive of computer 1 left to position A pole 1 and computer 2 left to position B pole 1, then the common terminal of that pole wire going out to the left input of your speakers. Wire up all six and you have a 5.1 A-B Box.

Brandon Spivey, Nashville, TN



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Bullet Style B/W Camera

- Weather Proof
- Signal System: EIA
- Image Sensor: 1/3" **LG CCD**
- Effective Pixels: 510 x 492
- Horizontal Resolution: 420TV lines
- Min. Illumination: 1Lux/F1.2

Item# VC-305

Details at Web Site

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Item# CSI768

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Details at Web Site > **Soldering Equipment & Supplies**

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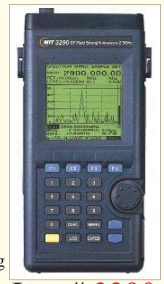

The **3290** is a high quality hand-held RF Field Strength Analyzer with wide band reception ranging from 100kHz to 2900MHz.The 3290 is a compact & lightweight portable analyzer & is a must for RF Technicians. Ideal for testing, installing & maintenance of Mobile Telephone Comm systems, Cellular Phones,Cordless phones, paging systems, cable &Satellite TV as well as antenna installations.May also be used to locate hidden cameras using RF transmissions.

Item# 3290

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(Includes Antenna)

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- Effective Pixels: 510 x 492
- Horizontal Resolution: 380TV lines
- Min. Illumination: 1Lux/F1.2

Item# VC-305CP

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The LogicPort provides 34 sampled channels including two state-mode clock inputs. It connects to your PC's USB port for ultimate convenience and performance.

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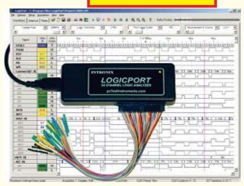

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Each	10+	25+	100+
$9.95	$8.95	$8.49	$6.95

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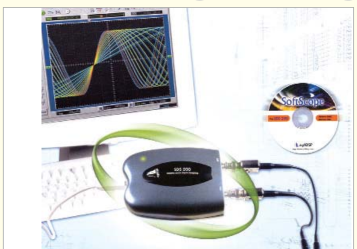

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480 TV Lines Resolution

- Day & Night Auto Switch
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- Min. Illumination: 0Lux

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- Day & Night Auto Switch
- Signal System: EIA
- Image Sensor: 1/3" **SONY Super HAD CCD**
- Horizontal Resolution: 420TV lines
- Min. Illumination: 0Lux

Item# VC-317D 1-4:$69.00 5+:$65.00

SONY Super HAD CCD Color Camera

- Weather Proof
- Signal System: NTSC
- Image Sensor: 1/4" SONY Super HAD CCD
- Horizontal Resolution: 420TV lines
- Min. Illumination: 1Lux/F1.2

Item# VC-805 1-4:$69.00 5+:$65.00

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- Signal System: NTSC
- Image Sensor: 1/4" **SONY Super HAD CCD**
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- Min. Illumination: 0Lux

Item# VC-819D

1-4:$89.00 5+:$79.00

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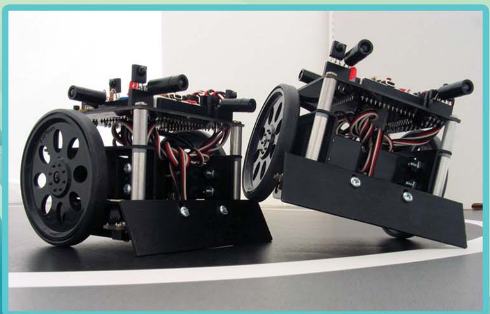
Through December you can purchase the SumoBot Competition Kit at **$179**, *$20 off the regular price of $199.00*. You'll either be adding a bit of entertainment to your holiday parties, or hiding in your computer room with your favorite gearhead.



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